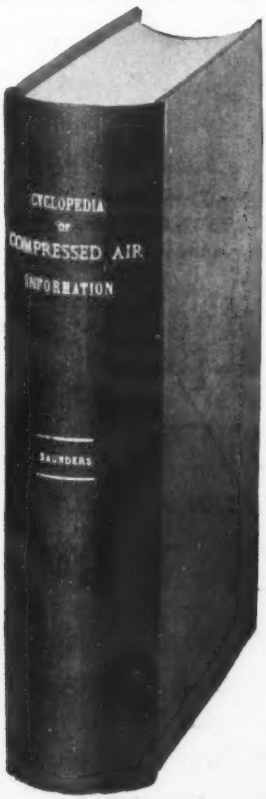
Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, NOVEMBER, 1902. No. 9.



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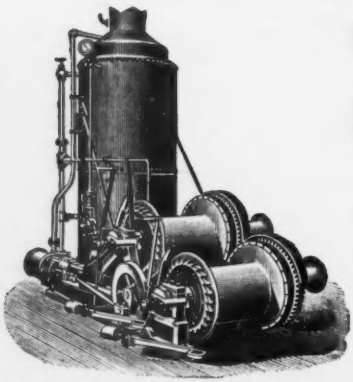

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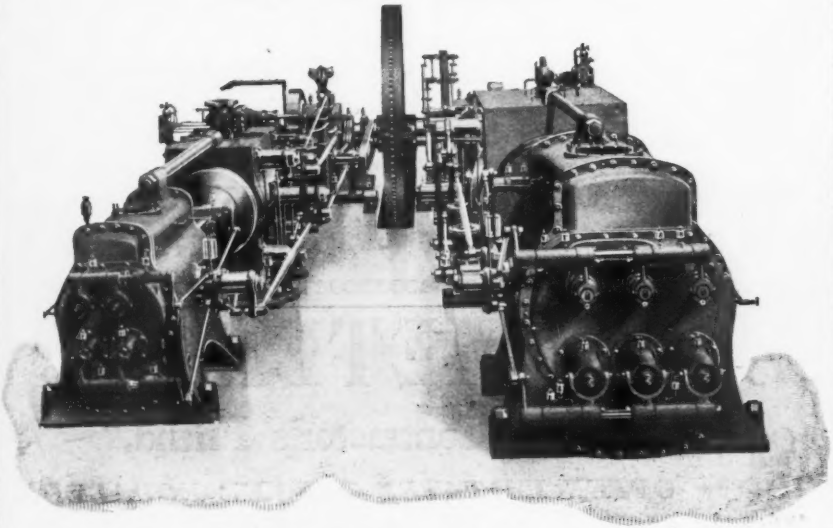

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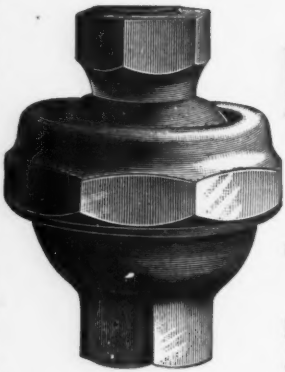

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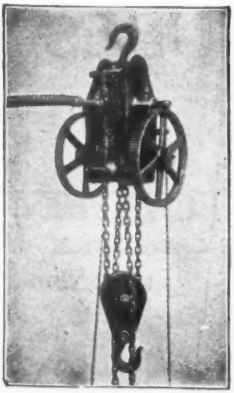

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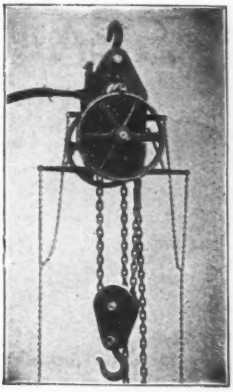

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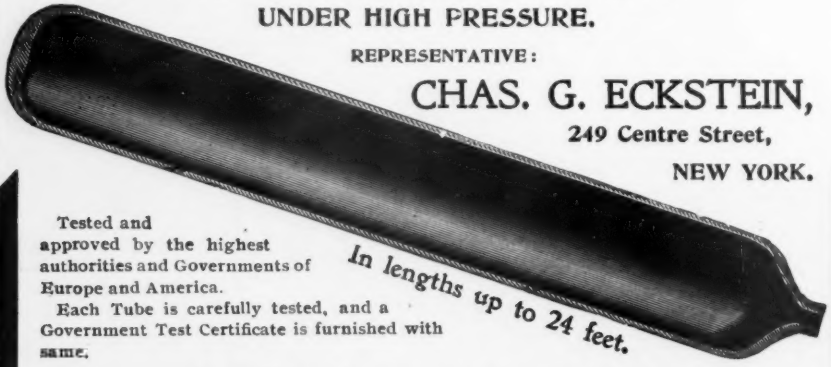

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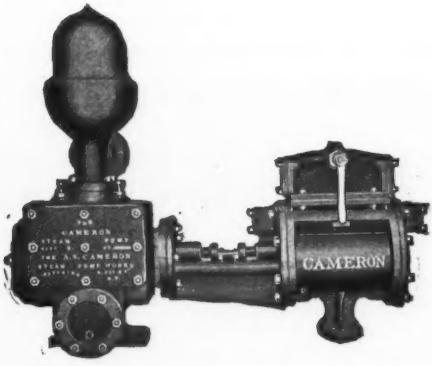

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VOL. VII. NOVEMBER, 1902. NO. 9.

Test of a High Lift Air Lift Plant at Grinnell, Iowa.

The subject of compressed air for raising water from artesian or deep wells is receiving more and more attention, and considerable information is being accumulated, obtained from actual experience, which cannot help but be of great value to anyone interested in this subject. In this connection the recent tests of a high lift air lift made at the water works of Grinnell, Iowa, are of considerable interest.

The air lift plant at this place consists of a 12 and 12x12-in. Class "F" Ingersoll-Sergeant Compressor for low pressure, and a 12 and 5½x12-in. Class "F" of the same make for high pressure. There is also a receiver 6 inches in diameter and 20 feet long, and an intercooler for reducting the temperature of the air, consisting of 50 feet of 2-inch pipe placed in a water box. The available boiler pressure for operating the compressor is from 70 to 80 pounds.

The well uses the Pohlé system of piping with a 3½-inch water pipe and a 2-inch air pipe placed outside of the water pipe. The depth of well is 2,000 feet, and the length of the air pipe from 504 to 557 feet. In the tests the water was discharged at 3 feet above the ground, and all measurements were taken from this point. The well has a 10-inch casing at the top down to the rock, where the diameter is reduced to 6⅝ inches. The water stands in the well at about 242 feet below the ground surface, when the well is not being pumped.

The compressors used in the test were second-hand machines, and were not in very good condition, and all the pistons and valves on both steam and air ends were very leaky. On this account the actual free air obtained was much less than the stated piston displacement capacity of the compressors.

The following table gives the results of the test:

TEST NUMBER.	2	8	16	18
Date: August	8th.	12th.	16th.	19th.
Feet of air pipe	504	557	557	504
Starting pressure	113	138	138	113
Running pressure	106	133	132	108
Air friction	3	2	1	1
Net well pressure	103	131	131	107
Lift in feet	267	258	258	254
Per cent. submergence	47%	53.6%	53.6%	50%
Gallons per minute	136	129	123	104
Speed rev. low pressure comp.	110	110	90	100
Cu. ft. piston displacement	165	165	135	150
Cu. ft. air per gallon	1.2	1.28	1.1	1.5
Per cent. efficiency	32.5	25.4	29.6%	
Intercooler pressure	52	50	55	
Speed high pressure compressor	135	110	80	

Referring to these tests, it should be noted that the water obtained in test No. 2 was measured in a barrel. In the later tests a reservoir was used, giving more accurate results and showing that the ratings obtained when the barrel was used were too high for identical conditions.

Test No. 16 was the official six-hour run and the figures given are averages for all observations during the run.

The intermediate tests, 3, 4 and 5, etc., are not included, as they were only experiments to determine the most economical speed.

By way of comparison a test was also made of this well, using a deep well pump. The results obtained with the deep well pump during a period of five hours are as follows:

Average amount of water pumped, 75 gallons per minute.

Feed water used, 390 gallons.

Quantity of water pumped, 22,500 gallons, or 57.7 gallons per gallon of feed water.

Referring to test No. 16 in the above table, which was a six-hour run, 44.4 gallons of water were pumped for each gallon of feed water. The difference between this figure and the 57.7 gallons pumped with the deep well pump being accounted for by the fact that the exhaust from the steam pump was partially condensed in an open heater and only cold water was metered, while in the case of the compressor test only the exhaust from the low pressure compressor was used in the heater. It was considered that this was sufficient to account for the differences.

Colliery Ventilating Machinery.*

In the operations of coal mining, which, in the United Kingdom alone, produce something over 225,000,000 tons a year, and find employment for nearly three-quarters of a million of people, there is nothing of more vital importance than the continual supply of a sufficient volume of fresh air for diluting the noxious gases prevalent in the mines and for enabling the underground workers to breathe a comparatively pure atmosphere. It may be said of modern mines that the efforts to provide this air have, in the majority of cases, been attended with so much success that the atmosphere of a modern coal mine is superior to the atmosphere of the forge or factory on the surface. The particular amounts of air required at the various collieries depend somewhat upon the nature of the mine, whether non-gaseous, or slightly gaseous, or very gaseous; also upon the number of human beings and animals employed in the mine; and on the amount of coal produced, which is not always in proportion to the number of persons engaged therein.

Taking all classes of coal mines, a fair and liberal consumption (and the allowance so as to be sufficient for all contingencies should be liberal), in the writer's opinion, is from five hundred to one thousand cubic feet of air per minute for each human being employed in the mine. Authorities differ very much as to the quantity, and even the lesser of the amounts stated will, in many quarters, be considered excessive; but they are not exaggerated amounts, and there are exceptional cases where even the larger quantity could, with advantage, be greater rather than less. Taking the total number of persons employed in and about the mines of the United Kingdom as three-quarters of a million, nearly 600,00 of this number will be employed underground, and the consumption of air, on the lower basis stated, for such an army of workers will amount to something like eighteen thousand million cubic feet per hour, representing in terms of weight more than half a million tons.

Making a comparison between the weight of the coal raised and the weight of air which passes through the mine in the length of a year, it has to be remembered that whilst coal production is not continuous, and in many cases occupies less than half of each twenty-four hours, and not always six days in the week, good ventilation at collieries means that the current is practically continuous from January 1 to December 31, day and night, Sunday and week day. Following out the

* Written by C. M. Percy, F. G. S., for *Cassier's Magazine*.

figures given above, it is found that the weight of air which ought to pass through the mines of the United Kingdom in a year is not less than four thousand million tons, or something like twenty tons of air for each ton of coal produced. It is not too much to say that, taking the coal mines of the world, the weight of air passing through them for purposes of ventilation exceeds the weight of all the minerals raised, even if the generous, although necessary, maximum estimate of one thousand cubic feet per minute per individual be reduced one-half.

In the days of our forefathers, when the coal mines worked were very shallow and the output was very limited, the ventilation provided was trivial, and in not a few cases was obtained by the action of the mine itself, the difference in temperature of the atmosphere of the mine and of the atmosphere at the surface being sufficient to generate some current.

Coal mining is very different at the present day. Nearly all the mines in the United Kingdom are of considerable depth, measured in hundreds of yards. The great expense of putting down a colliery to such depths, and the cost of machinery to deal with coal from such depths, make a large output from a large area necessary, and require the employment in one mine of a large number of persons. Such a condition of things demands so large a volume of air for ventilation that it can be supplied only by artificial means.

In the first half of the last century what is known as furnace ventilation was almost universal. A large fire was maintained at the bottom of the outlet or upcast shaft, and the heat, acting upon the air in this shaft, caused expansion, diminishing the weight of the column in this shaft, and enabling the colder and heavier air in the inlet or downcast shaft to descend; thus a current was produced. This method of ventilation was effective and capable of very large volume, but was not economical; it also entailed danger from fire. As a matter of fact, very few such furnaces have altogether avoided setting on fire the coal in their vicinity, and they did not possess the facility necessary for maintaining a uniform current, or, when necessity required, for varying the volume expeditiously. During the latter half of the last century all methods of producing the ventilation of a colliery except the mechanical have been gradually falling into disuse, and practically all new collieries adopt machinery for this purpose.

That useful piece of machinery so common at every colliery, namely, the pump, has proved itself so excellent for dealing with volumes of water, however large, that it was not strange for some of the first attempts with mechanical ventilators to proceed on those lines. These ventilating pumps were not measured in inches of diameter or even feet, but by yards, and were encumbered with numerous, and large, and heavy clacks or valves. The chief efforts in this direction were by Struve, and Goffint, and Nixon, and from experiments made, when working at a low speed and dealing with a small volume over a short period, seemed to give encouraging results; but the great size and weight of the reciprocating parts made anything approaching a high speed impossible; and the wear and tear of the valves and the machinery generally caused frequent stoppages for repairs. This latter defect was fatal; colliery ventilation cannot be effective unless it is continuous. It was not long after the first attempts at mechanical ventilation—although a variety of contrivances were designed by Lemielle, and Fabry, and Cooke, and Root, and were constructed and worked with varying and inconsiderable success—before it became evident that the effective machine, before which all others would disappear, was the centrifugal fan. This combined simplicity and practically everlasting wear, and efficiency with economy; and at the present time at least 90 per cent. of all the ventilating appliances at work are of the fan type. The fan is connected with the outlet or upcast shaft at the top of the shaft by a drift or airway entering that shaft at or just below the surface, and arrangements are made that no air can reach the fan except from the mine through the upcast shaft. The air enters the fan at one side, or both sides, the latter being preferable.

There have been discussions at times as to whether air should be forced into a mine at the downcast shaft, or drawn from a mine at the upcast; so long as we get the needed volume through the mine, however, it matters little which method is adopted. Although the large majority of colliery ventilators are exhausters, they might probably with equal advantage have been applied as pressure ventilators. In some special cases the ar-

rangements made are such that the same fan can work either as one or the other. In the pressure system we have a less volume, because nothing passes the fan except pure air, and the fan is not exposed to the corrosive influence of noxious gases. In the exhaust ventilator we have probably less pressure and strain upon the fan itself. The most reasonable explanation for the almost universality of exhaust ventilators is that, having no strong reason to the contrary, and the pioneer appliances, such as the steam jet and the furnace, having been associated with the outlet or the upcast shaft, the modern appliance followed on the same lines.

The useful work of ventilation is represented by the volume of air that passes through the mine, and all leakage in from the surface to the fan is so much work lost; hence means have to be adopted to prevent air getting into the fan except from the mine, and special precautions must be taken, because air will so much more easily enter from the surface than through the long passages of the mine. The best modern practice is to use the outlet or upcast shaft for ventilation only, and under these conditions the course is clear and this shaft is covered over. But generally the outlet or upcast shaft is a regular winding shaft, and the arrival and departure of the cages complicate the situation and make some leakage inevitable.

There seems no simpler or more effective plan under such conditions than that which was first introduced, namely, to enclose the pit framework and have on each side of that framework a commodious chamber for loading and unloading the cages. There are doors between these chambers and the pit bank outside, and there are doors between these chambers and the outlet or upcast shaft; these enable the cages to be loaded and unloaded without any serious leakage. It might be said that such an arrangement prevents the winding engineman from seeing the cages; but this is not necessarily so, because glass may be inserted and the electric light applied; and even if the winding engineman cannot see the cages, there is no difficulty with an effective code of signals, which in any case must be the only communication between the winding engineman and the cage at the bottom of the shaft.

The centrifugal fan easily separates itself into three great classes, namely, first, the open running; second, the close casing and enlarging chimney; third, the spiral casing terminating in a chimney; and as practically all the good ventilating machines used belong to one or other of these classes, this article will confine itself to them, the purpose being not to discuss all manner of ventilating machinery, but simply its most important and successful forms.

OPEN RUNNING FANS.

We include in the open-running class all fans which take air in on one side or both, and discharge it freely all round the circumference into the open. In Nasmith's arrangement there was simply a revolving wheel between two fixed sides, and a number of deep, rectangular, radial blades. The Biram fan was rather different, the blades being not nearly so deep, measuring only a tenth of the radius of the revolving part; that was a disadvantage. The blades also were inclined backwards, so that the root of one blade was in a radial line with the tip of the next blade; that was an advantage. In the Hopton fan the blades, which are of conconsiderable depth, are arranged to curve backwards, and each blade passes tangentially into the circumference. The Marsden fan dispenses with blades, and the connection from inlet to circumference is by means of a number of tubes which curve backwards; the sides revolve with the fan.

A very popular form of open-running fan is the Waddle. The air enters on one side only, and the whole appliance revolves, thus making leakage at the sides impossible. The passage from the inlet, to the vertical plane of the fan, is curved, and the cross-section area of each division diminishes so that the circumference at any point, multiplied by the cross section area at that point, is a constant quantity. The blades or partitions, which incline backwards, do not extend to the periphery, and the space within the fan beyond the tips of the blades is bell-mouthed.

CLOSE CASING FAN AND ENLARGING CHIMNEY.

Quite a number of different types of this class of fan have been introduced on the Continent of Europe, but the only one that has made any headway in the United Kingdom is that which bears the

name of the Belgian engineer Guibal. We owe a great deal to this inventor and his invention. Previous efforts to introduce mechanical colliery ventilators had proved so far from successful that it almost appeared as if such men as Nicholas Wood and William Fairbairn were right when they stated that no machine could do for colliery ventilation what furnaces were doing. The Guibal fan was from the first a substantial success. The air enters on one side, or both, and the blades, which are deep and rectangular, incline backwards, and curve at the tips radially with the circumference. The casing is a fixture, and comes within simple clearing distance all round the circumference except for about a tenth of the whole, near the bottom. This opening, which can be increased or diminished by a sliding shutter, delivers into a chimney which increases in cross-sectional area to the top. There is no doubt that the success of the Guibal fan was, and is, due to its chimney.

Recognizing that the air must leave the revolving part of the fan at a high velocity, representing so much energy, the enlarging chimney receives the air at that high velocity and, by its increasing area, diminishes the velocity, and utilizes the liberated energy in overcoming all pressure within the chimney and actually producing a partial vacuum. A two-fold benefit arises—the delivery from the fan itself is expediated because resistance is removed; and the air passes easily out of the chimney into the open.

There have been at least two distinct improvements in the original Guibal fan. Cockson modified the form of the blades so as to give a uniform passage for the air through the fan, and to make the pressure uniform on the blade. Messrs. Walker Brothers, of Wigan, modified the shutter, which, being rectangular, caused each blade to lose all its pressure instantaneously, producing as many shocks and vibrations in each revolution as there were blades. This caused a good deal of wear and tear, and limited the speed. The Walker anti-vibration shutter, formed like a reversed elongated letter V, so A, avoids absolutely the shock of each blade passing the shutter; this made a considerable increase of speed,—therefore volume and water gauge,—possible with less wear.

SPIRAL CASING FANS.

In these fans there is a spiral casing which affords an opening from the revolving part all round the circumference, the cross section area of the spiral casing increasing to the chimney. The Schiele fan, which appears to have led the way in this class, has blades slightly curved backwards at the tips, just the reverse of the Guibal. The other portion of each blade is straight and inclined backwards, and the edges are so formed that the passages through the fan maintain a uniform cross-section area from inlet to circumference.

What is known as the Walker "Indestructible" fan has been before the mining community for many years, and, so far as the United Kingdom is concerned, more fans of this class than of any other have been applied at collieries. The chief points aimed at by the makers were to produce a ventilating machine which should obtain a high percentage of useful effect, without the great weight, unwieldy dimensions, or expensive foundations of the large direct-driven fans; and which should possess the strength, rigidity, and durability of the smaller fans whilst avoiding their excessive speed and probable trouble with heated bearings. There are two strong cast-iron bosses, carefully bored out and made a good fit on the fan shaft, to which they are secured by steel keys. The extension lengthwise of these bosses distributes the weight of the fan over the shaft. Between the bosses are two discs of steel which fit the fan shaft. Each disc is in halves, the joints being placed at right angles, thus forming one double disc of great strength. Between the two discs the iron arms of the fan are fixed "sandwich"-like and gripped tightly. These arms extend from near the axis of the fan to its periphery, the discs supporting them half way. Angle irons are riveted to the fan arms beyond the discs, and to these angle irons the blades, usually eight in number, are firmly secured. The blades, which spring tangentially from a small circle concentric with the fan shaft, are curved longitudinally, to the arc of a circle of a certain radius, and are cut away from the edge of the inlet of the fan shaft, to minimize central resistance.

It is very necessary to minimize the slipping of the air between the sides of

the blades and the walls of the fan chamber as far as practicable. The blades, being strong, cannot be brought close to the walls, as in the event of any side movement of the fan on its bearings they might "catch." The clearance, therefore, is made up by attaching strips of pliable hoop iron to the sides of the blades.

The Walker anti-vibration shutter (although a spiral casing surrounds the fan), referred to elsewhere in this article, is applied with effect to this fan. It may be of interest here to relate that several years ago Messrs. Walker Brothers had erected three ordinary Guibal fans for ventilating a portion of the London Metropolitan Underground Railway, and, although the fans were effective enough in producing volume of air, the pulsations or vibrations exercised an injurious influence upon the windows and doors of the surrounding buildings, and unpleasant proceedings were threatened. The application of the anti-vibration shutter saved the situation in this particular case, and the appliance has now become a useful appendage to ventilating fans at hundreds of collieries. The Capell fan has two parts revolving together, the inner part being really a drum with openings in the circumference, and the outer part being open to the spiral casing. The blades are curved backwards in each part, and the claim is that there is a utilization of energy not only between the outer part and the spiral casing, but also between the inner part and the outer. There always seemed to be room for doubt as to whether this double endeavor to utilize this energy was necessary or desirable, and later improvements would appear to be on lines depending on the conversion of the energy at one operation between the fan and the casing and chimney into which the air discharges. The chimney of the Capell fan differs from the Guibal as the cross-section area increases more rapidly; in the former the enlargement is on two sides, whereas in the Capell the enlargement is on all four sides.

The advantage of the open-running fan is its simplicity, and there is no elaboration of the surrounding structure; the air is not obstructed in leaving the fan at any point of the circumference. But the inseparable defect would seem to be that the air cannot avoid leaving the fan at a high velocity, and the energy represented in this velocity may be very serious and is wasted. In the close casing and the enlarging chimney this is avoided. The defect of the close casing would seem to be that it prevents free outlet for the air, and forcing some of the air through nine-tenths of the circumference against its natural inclination must generate friction and absorb work. Also there must be an increasing pressure on each blade from the time of passing the outlet to arriving at it again, and such an inequality of pressure does not encourage high speed.

The fan with the spiral casing terminating in a chimney would appear to combine whatever is advantageous in the two other classes, and avoids their defects. The spiral casing affords free outlet from the revolving part of the fan all around the circumference, and extends the advantages of the enlarging chimney for diminishing velocity and utilizing energy all around the circumference.

Opinions differ as to the correct form of fan blades. It seems right that the passage for the air through the fan should be in as direct a line as may be. Mere revolution means simply "churning" the air and setting up frictional resistances. A particle of air moving radially along a revolving disc traces a line more or less curved backwards, according to the speed of revolution of the disc and the radial speed of the particle; and this backward curved line will pass easily into the circumference. That would appear to be the correct form of the blades, and in the open-running fan that should be the form of the blades; but in the close-casing fan, such as the Guibal, this would hardly apply, because the air, however it travels from the inlet, can leave the fan only at the place provided. And it is probably not of very great importance in the fan with the spiral casing, because whatever velocity the air may possess in leaving the fan is taken from it before being discharged into the open. Still, any change in form of fan blades from the radial should be backwards and should be curved.

When ventilating collieries by machinery was new and there was no experience to guide the makers or purchasers, a good deal of constructing was done by rule of thumb. But years of experience with many thousands of ventilating installations under all possible conditions have enabled the laying down of fairly accurate practical rules of design.

It is quite evident that no fan, however excellent, will produce a current unless the passages in the mine will allow the air to get to the fan. Strange as it may seem, many mines have excellent fans, but deplorably poor air-ways. What is called the "equivalent orifice" of a mine is the smallest area in square feet which will pass a given volume of air in a minute with a given water gauge in inches. Assuming the orifice to be through a thin plate, the rule for its area is—multiply the volume of air in thousands of cubic feet per minute by 0.37 and divide by the square root of the water gauge in inches. With this as a basis we may design a fan. Each of the two inlets should be equal to the "equivalent orifice" so as to make allowances for resistances within the fans, and the passage through the fan should be equal in area to at least that of the inlet or inlets.

It will be seen that for a given volume the "equivalent orifice" will be larger for a low water gauge and smaller for a high water gauge. The writer has assumed a medium water gauge for mines in the United Kingdom of two and a half inches, and has also adopted two inlets, each being equal to the "equivalent orifice." Laying down a practical rule that each inlet shall equal the "equivalent orifice," that the fan shall have a diameter equal to twice the diameter of the inlet, and that the width of the fan shall be approximately one-third of the diameter of the fan, we arrive at the results given in the table.

With proper conditions, the water gauge will depend upon the speed of the circumference of the fan—will, in fact, increase and decrease as the square of the velocity. The water gauge itself is a bent glass tube,

Cubic Feet of Air per Minute.	Diameters of Each of Two Inlets. Feet.	Diameter and Width of Fan. Feet.
50,000	4	8 x 3
100,000	6	12 x 4
200,000	8	16 x 6
300,000	10	20 x 7
400,000	12	24 x 8
500,000	13	26 x 9
600,000	14	28 x 9
750,000	15	30 x 10

open at both ends and fixed vertically, one end connecting with the open atmosphere, say, in the engine house, and the other end with the airway or drift leading to the fan, and preferably, for accuracy of result, sufficiently far removed from the fan itself to be free from contending currents and eddies which are unavoidable in the inlet, or close to it. There is water in this appliance, and the influence of the fan lifts the water in one leg and depresses it in the other. Of the difference in level, each inch represents a pressure of 5.2 pounds per square foot, being simply the weight of a column of water one inch high and a square foot in area. Knowing the speed of the circumference of the fan in feet per second, we square it, and divide by 64, which gives us the ventilating column in feet. Brought into inches and divided by 800 (because water is practically 800 times heavier than air at atmospheric pressure), we arrive at the water gauge in inches for a given speed of circumference of the fan. The friction of the air increases as the square of the velocity; therefore the water gauge produced increases with the square of the speed of the fan. The power has to overcome increased friction and increased volume; therefore the power increases as the cube of the speed of the fan. The horse-power of ventilation is the quantity of air in cubic feet per minte multiplied by the water gauge in inches and by 5.2 and divided by 33,000. The usual effect or efficiency of a fan is the proportion of the power consumed to the power of the fan engine.

The general method of arriving at the efficiency leaves much to be desired. The power of the engine usually taken is the indicated horse-power, which includes the engine resistance, representing perhaps 20 per cent. of the indicated power. Why should a fan be charged in its balance sheet with power that it never receives, and how can we compare two fans on these lines, if one has a good engine and the other has a bad engine? The engine power should be the useful work which an engine has available after accounting for its own resistance, which resistances are rarely the same in any two engines. Then, again, the water gauge is often not taken with sufficient accuracy, and, still further, the actual volume of air passing is not known because the linear velocity is not measured correctly, and the same remark applies to the area of the passage leading to the fan. There is much to improve upon in determining the useful effect or efficiency of a fan. The method laid down

in this article for determining water gauge from speed, or speed from water gauge, is not that which is usually adopted and which gives a water gauge twice as great as here set out; but the water gauge obtained by modern rules is the "manometric depression," or theoretic efficiency of a fan; and as the water gauge in practice is rarely more than one-half of this theoretic quantity, the rule followed in this article is not necessarily in contradiction, and simply brings us to the actual and practical water gauge obtained by a fan by a shorter route.

So far as the fans themselves are concerned there are now any number of admirable examples, excellent in design and construction, capable of running with absolute truth upon their bearings with a minimum of resistance, and also of running continuously for many years without any necessity of stoppage for repairs. The method of driving, however, is not nearly so universally good. There are, it is true, some very good examples of fan engines, but the majority are not of that kind. The extravagance of colliery machinery generally is not a creditable feature of the age. In connection with one important class—winding engines—some excuse can be found for it. Such engines work intermittently, rarely for as long a period as a minute for a journey; start from rest and reach a high speed, then fall away from that high speed to rest—all within this just-mentioned short period; and they must be easily capable of starting from and stopping at any point. But even with this class of engines improvements are being made, and condensing and compounding are being introduced.

With ventilating machinery the work is almost absolutely uniform and continuous, without stoppage, day and night, from January to January. Such a condition of things invites and encourages all that is perfect in the economics of engineering. But it would be no exaggeration to say that a considerable proportion of fan engines are still not only non-condensing, but only very slightly expansive. An engine of that type will consume from six to eight pounds of coal per horse-power per hour, as compared with a pound and a half of coal per horse-power per hour in a truly economical engine.

The best arrangement of engines for driving a fan would probably be a pair of horizontal, triple-expansion condensing engines, placed at right angles, attached to separate cranks, and so arranged that they can work together as a pair, or, if repairs should be necessary, one engine could be disconnected and the other engine alone continue to drive the fan. If the first expense could be met, an even better arrangement would be to have two distinct and self-contained ventilating plants, so that with two fans and two engines there would be opportunity for overhauling one fan and one engine without interfering with the ventilation. There is at least one colliery known to the writer at which such an arrangement has been adopted.

In the early mechanical ventilators, which were usually on a large scale, and did not make a great number of revolutions per minute, the engine was connected direct to the fan, and this caused a two-fold defect as time went on. Either the engine had to run very quickly indeed, which is not desirable even now when running continuously for months, or the fan had to be made very large in diameter to obtain a sufficient circumferential speed. The massive fans of a quarter of a century ago, of 45 feet and even 50 feet in diameter, were cumbersome structures, requiring large and expensive foundations, and absorbing much power simply to keep them in motion.

It has been proved that in coal mining practice such mammoth sizes are not necessary as regards volume. A million cubic feet of air per minute at the ordinary water gauges can be produced with a diameter of 30 feet, and no one mine is likely to need so much; and as regards the amount of depression or water gauge required, that depends not on the diameter, but on the speed of the circumference. A fan 5 feet in diameter, running at 500 revolutions per minute, will have the same speed of circumference, and therefore produce the same water gauge, as a fan 50 feet in diameter running fifty revolutions per minute.

The best modern practice is to run the fan engine at a moderate speed, say, 400 piston-feet per minute, and to get up the requisite speed in the fan by gearing. Spur wheels have nothing to recommend them except their positive action, which, with a fan, is not absolutely essential. Straps have answered well enough, and are fairly noiseless, but there is a difficulty in the transmission of large powers in obtaining straps of a reliable quality and

sufficiently flexible. Round cotton ropes, usually about 1½ to 2 inches in diameter, running in carefully prepared grooves, answer admirably; there is scarcely any wear and tear upon the ropes, because, as a large number is usually applied to drive the fan, the amount of pull on each single rope is only slight. The ropes give a better grip even than flat straps, and, if anything, are more free from noise in action.

The speed of the fan depends altogether on the amount of depression or water gauge required, which in the mines of the United Kingdom does not often exceed about 4 inches, unless in exceptional parts of the mine, where small auxiliary fans may be applied. But all well-designed and constructed fans of the present day should be capable of running without injury at a circumferential velocity of, say, 12,000 feet a minute, which would obtain a water gauge of nearly 12 inches. There is really no difficulty in speed, so far as the fan itself is concerned; that is merely a question of sufficient strength, accurate balancing, and true bearings. There have been difficulties in keeping the fan shaft journals from heating, but those difficulties are disappearing before modern mechanical engineering improvements.

It will have been gathered from this article that in the United Kingdom no ventilating machine has been largely and successfully applied to collieries except the centrifugal fan, which, being a simple wheel, if made strong enough and properly balanced, can run at any reasonable speed, and has really nothing to get out of order. These fans should be of moderate dimensions; a diameter of 30 feet might be taken as a maximum for a volume extending to, say, three-quarters of a million or even one million cubic feet per minute. There should be two inlets to each fan; the diameter of the fan might be taken for any particular case as twice the diameter of the inlet; and the width one-third of the diameter of the fan, which should be driven by a pair of triple-expansion engines transmitting their power through rope gearing.

The fan should be of the class with spiral casing terminating in a chimney, and should have a strong central diaphragm, preventing the meeting of the currents from the two inlets. Such an arrangement might be used effectively either to force air into the inlet or downcast shaft, or to draw air out of the outlet or upcast shaft, and in either case careful means should be adopted for sealing the pit shaft at which the fan is placed, so that, if situated at the downcast shaft, there is no passage other than through the fan, and, if located at the upcast, also no means of communication except through the fan. The water-gauge appliance, for measuring the effective depression, should be a few yards distant from the fan itself; the useful effect or efficiency of the fan should be based not upon the indicated horse-power, but the useful horse-power of the fan engine. The colliery manager or mining engineer should not be content with providing ventilating machinery of the highest character, but should remember that as no pump can deal with water unless the suction passages are clear, and as no winding engines can raise a load unless the rope is attached to the cage, no fan can do justice to itself or its owner unless the passages in the mine are sufficient to allow the air to reach the fan.

First Aid to the Injured in Mining Accidents.*

The causes of mining accidents are too numerous and varied to permit of a distinct classification. Those most constantly operative are falls from roof and sides, use of explosives, foul gases, operation of hoisting and traction machinery, explosion of inflammable gases (coal mines), traversing ladder ways, placing of timbers. Under the term miscellaneous may be grouped all others which contribute in any degree to the production of accidents. While many accidents from the nature of things are unforeseen and unavoidable, it is to be regretted that a certain percentage far too great is due to either carelessness or disobedience of the rules established for the protection of all, including those who habitually transgress them. It seems almost incredible that men should persist in dangerous and forbidden practices which imperil the lives of others as well as their own merely to save time or avoid a little additional work; yet this is often done with no apparent concern as to what may happen in consequence. This indifference to danger is perhaps not intentional;

* A paper read by Dr. G. W. King, Helena, Mont., at the Butte, Mont., session of the Mining Congress, September 3, 1902. Specially reported for the MINING AND SCIENTIFIC PRESS.

constant exposure without injury begets a disposition to underrate the liability to accident and the necessity of guarding against them. This fact, however, does not excuse one who commits a rash act or who by negligence sacrifices the lives of his fellow-workman instead of contributing his share to their preservation by more careful attention to duty. The most reliable guarantee of safety must be based upon the practical knowledge possessed by the miner himself. He is expected to understand the nature of the ground in which he works, the proper manner of breaking it, the support required during and after the extraction of the ore, the precautions to be taken for the safe handling of explosives—in short, the whole procedure is in his hands and the safety and efficiency of the work depends upon the skill and judgment exercised in its accomplishment. Self-protection is a matter of individual responsibility in so far as the immediate surroundings are concerned, and should be the first consideration in all that is undertaken. The conditions which pertain in mining differ materially from those that exist in ordinary labor above the surface of the ground. The miner, for instance, must work by the aid of a candle or safety lamp, and such light may prove inadequate for the close inspection of loose rock in the roof and sides of levels and stopes, and unless special care is taken dangerous indications may be overlooked even by a careful and competent observer.

These are some of the common and ever recurring situations under which the work is done. Something more than the mere ability to perform manual labor is demanded; there must be skill to direct and govern every act; mistakes are perilous by the swift and destructive consequences which may follow. To become skilled as a miner an apprenticeship more exacting than that practiced for the various trades must be accepted as the true method of training.

Looking a little further into the causes of mining accidents we find an appreciable number chargeable to the use of explosives. The agent most generallv employed is nitro-glycerine, known to the trade as dynamite or giant powder. This substance is reasonably safe at a moderate temperature and under ordinary atmospheric conditions, but is always to be regarded with suspicion and few liberties taken with it, as no one can as yet determine the exact explosive point at any time or place, much less the influences which lead up to it and induce a state of extreme sensitiveness which responds to the slightest jar or vibration. It possesses the disadvantage of readily congealing at a lowered temperature, necessitating the application of heat to expel the frost before using. This latter process is a source of real danger and ought not to be trusted to inexperienced hands, or to any one for that matter without the proper appliances for regulating the heat to safe limits. The method which gives the best security is that by which a moderate and uniform temperature is maintained, the placing of a competent man in charge of the process whose duty it is to supply the miners with powder and fuse upon requisition. Accidents which occur while charging the holes or from mistakes in length of fuse, neglect in signaling, defect in arranging facilities for retiring to a safe distance, are for the most part preventable and the fault lies with the workmen themselves.

The equipment of shafts operated by means of cages has been so well perfected that comparatively few accidents are noted if we take into account the amount of work done and the number of men transported to and from their work from month to year in the various mines that are in active operation. When an accident does occur in connection wth the working of a shaft it is usually a serious one. The parting of a cable, the sudden giving of the brake upon the hoisting engine, a failure of safety clutches, overwinding and precipitation of the cage to the bottom of a deep mine—any one of these unfortunate mischances must necessarily be attended with loss of life.

In sinking winzes and working shafts in the less pretentious mines, buckets are used to convey men and for general use in hoisting. The bucket when working without guys is not under absolute control, and when propelled at a high rate of speed assumes a rotary motion,, which is apt to cause vertigo in some individuals to such a degree as to render them incapable of retaining their grasp upon the cable, as in one instance coming to the writer's notice, that of a miner falling from a bucket in making a descent of 200 feet in a vertical shaft. No other cause could be assigned. Closing the eyes tightly

will in a measure counteract the sensation of vertigo and prevent accident.

The speed should, however, be regulated within reasonable limits. The practice of riding upon a loaded bucket is unsafe and should never be done. Here is a case in point: Two miners were riding upon a bucket in which some pieces of lagging were being hoisted; neglecting to lash the top of the poles securely they came in collision with one of the timbers of the shaft, the cable was broken and the bucket, with its contents, was precipitated to the bottom with fatal results.

Other cases might be cited to prove that the practice referred to is a dangerous one, but the fact is too apparent to need further comment.

The handling of heavy timbers has its quota of mishaps, such as the breaking of ropes, slips and sliding ground risks that are usually unavoidable.

Machine drilling in mines is not especially dangerous. The few accidents that come under observation happen while setting up the machine or from the giving away of ground upon which it stands. Small particles of steel from the drill are liable to injure the eyes by becoming imbedded in the cornea. They are, however, readily extracted by applying cocaine, and using a magnetized instrument of suitable size. If the foreign body penetrates into the interior of the eye, the loss of that organ is a probable result.

Accidents met with in loading and coupling cars are usually of a minor class, and are in the majority of instances due to the want of care on the part of the workmen thus engaged.

Accidents from the inhalation of poisonous gases is a subject of special interest to miners, on account of their frequent exposure while working underground. The best ventilated mines are not entirely free from this danger, and as a consequence, miners are sometimes overcome by breathing gases collected or generated in stopes on recesses that cannot be wholly purified. Where good ventilation has not been provided, as in shafts and tunnels projected by prospectors, the danger is proportionally increased. The attempt to return too soon after blasting has occasioned loss of life. The introduction of compressed air as a motive power in the larger mines is of signal service in this particular. After blasting the air is turned on and the obnoxious gases driven out before the men resume their labor. The candle test for unsafe air is observed by miners generally. They know that an atmosphere too poor in oxygen to support the flame of a candle is unfit to breathe, and precaution must be taken to avoid such localities when it is possible to do so. They should also understand that this test is not infallible. There may be, and often is, an admixture of gases capable of supporting the flame from a candle, and yet deadly when inhaled. Experienced miners cannot have failed to note the behavior of the candle flame under these conditions. It flares up with a pale, bluish light, due to the presence of a gas known as "carbon monoxide." It is one of the most poisonous gases with which the miners come in contact. A product of imperfect combustion, it is generated by the detonation of explosive compounds, and being colorless, odorless and tasteless, its presence is only made apparent by certain symptoms produced by its poisonous action when introduced into the blood by continuous inhalation.

Associated with the ordinary carbon dioxide which infests mines in as small a proportion as 1 per cent., it may prove injurious. A combination of the two gases seems to increase the toxicity of each other. Carbon dioxide is fortunately less active than the monoxide; moreover, it has a slight taste and odor, and can therefore be more readily detected. The two gases are generally associated together, and the chief concern is to be able to determine when their percentage in the atmosphere has passed beyond the limit of safety.

It is true that a difference exists among individuals in regard to their susceptibility to the action of these gases. One may be overcome in a place where another suffers but slight inconvenience. This fact often encourages the latter to take unnecessary chances. Men of experience and judgment, however, rarely go into a place where the air is known to be bad without being prepared to retreat promptly upon the first indication of danger. What these indications are should be as familiar to the trammer as to the miner himself, for it is among the former class that accidents from inhalation of foul air is most liable to occur. Their work necessitates the handling of loose earth, which is more or less permeated by the gas which is easily freed by the disturbance and becomes

mixed with the air we are to breathe. Poisoning by carbon dioxide is at the time so insidious that the warning symptoms are unnoticed until too late to escape.

SYMPTOMS OF POISONING BY CARBON DIOXIDE.—The smell and taste of the gas is usually quite perceptible, and this indicates its presence when the percentage is small; nothing more than a dryness of the throat and a slight headache may be experienced. In large amounts the headache becomes more intense, a peculiar throbbing pain is felt over the brow and back of the head. Vertigo supervenes and the sight becomes dim and the limbs weak. There is a nausea and vomiting. An uncontrollable desire to sleep comes on and the person falls never to rise, unless carried out immediately. In an atmosphere completely saturated with carbon dioxide these progressive symptoms are not noted, for the reason that all is over in a very few moments.

The result is practically the same as being submerged in water. To rescue those who are insensible a systematic plan of relief should be adopted. To rush in excitedly but complicates the work, very likely adding to the number already disabled. By forming a relay of men and instructing the one who is to enter to apply a sponge or handkerchief saturated with water or preferably with vinegar over the mouth and nostrils, then go quickly forward, take hold of the one insensible and drag him to the entrance as far as he can with safety to himself, then retire to give place to the one who stands ready to succeed him, will render the rescue work less hazardous to all concerned. Operating in a shaft is more difficult and dangerous. When the descent is made by a bucket for any considerable distance through a poisoned atmosphere, it is impossible to stand erect within it and maintain an equilibrium after the paralyzing effects of the gas is experienced. A sitting or kneeling posture should therefore be assumed to avoid the possibility of being precipitated from the bucket. Should descent by ladder way be undertaken, a rope fastened about the waist and manned from above is recommended as a wise precaution. A second rope may be lowered, if necessary, and made fast to the person to be brought up by means of a loop drawn snugly around the body close under the arms. The act of hoisting an unconscious person by the aid of a rope must be conducted with reasonable care, the tension ought to be steady, lest too forcible contact wth jutting timbers or rocks result in serious injury.

The treatment of asphyxia produced by inhalation of poisonous gases will be referred to in appropriate connection.

The prevention of mining accidents has been the subject of much study, and investigation is continually being made by engineers and practical mining men. Legislatures have also endeavored to surround the miners with additional safeguards by legal enactments. Improvement has certainly been made, and with the advent of electricity for the purpose of lighting and motive power further progress will be made evident in the equipment of mines that are to be operated in the future.

Were it possible to exclude the accidents which are clearly preventable, the occupation of mining would be less hazardous and the mortality lessened, a result most helpful and worth striving for, since at best there will be fatalities enough and to spare.

Taking the practical view, then, that with the best equipment and most efficient service accidents may and do happen, the care of the injured must be considered with reference to their immediate necessities. To be prepared for emergencies is the first essential. This refers to the few medicines and appliances that may be needed for temporary use. These articles should be kept in reserve at the most accessible station within the mine, and plain and concise directions for their proper and legitimate indications posted in a conspicuous place, that all may learn how and what to do for others in case of need. To avoid unnecessary complications, the list of articles must be limited to the actual requirements, enumerated, it would appear, as follows: One-half dozen bandages, 2½ to 3 inches in width and 1 yard in length; one package of absorbent cotton; one roll of adhesive plaster; one dozen safety pins; galvanized wash bowl, soap and towel; temporary splints for the limbs; a litter; one cylinder of compressed oxygen gas, with inhaling mask; medicines other than stimulants are not indicated. Two ounces of aromatic spirits of ammonia, with a small flask of brandy, are added for the latter. The medicines and dressings may be stored in a tin box with a tightly fitting cover, and the whole protected from moisture. After an accident the danger to be

apprehended to those who are severely injured depends in a measure upon the length of time which must elapse before medical aid can reach them. This period varies from a few moments to several hours, according to circumstances. During this interval of waiting what is to be done? In some instances nothing; in others prompt action must be taken to save life. Upon those who are present, or first to arrive, devolves the duty of attending to the immediate necessities, whatever they may be, as best they can. The demoralizing effect of an accident upon those who witnessed it is apt to be harmful in two ways: First, by causing delay when time is the important factor; second, by inciting too energetic attempts at rendering assistance. It is, therefore, well to remember that, however alarming the situation, calmness and presence of mind are all-important.

Undue excitement contributes to render the chances of succor less certain, if not impossible. One who is competent to do the right thing whenever and wherever such service is imperative exerts an influence most assuring and helpful to those in peril, and to those who must assist in their care. Gentleness without timidity is of inestimable value in this service under all conditions.

In caring for the injured there are certain things to do, applicable in all cases, and we, therefore, begin by placing the individual in a recumbent and easy position, and proceed to loosen the clothing about the neck and chest, and if the patient is able to swallow and there is no excessive bleeding, external or internal, from wounds or concussions, a moderate amount of whiskey or aromatic spirits of ammonia may be given as a temporary stimulant. If stunned and unconscious, no attempt to give fluids by the mouth ought to be made, owing to the liability of their entering the windpipe and causing suffocation. Cold water may with advantage be sprinkled upon the face to excite effort at breathing. Friction applied to the extremities, being careful to select those which are injured, is a healthy measure. Heat applied externally is indicated when the surface of the body is cold and the circulation feeble. When reaction has become established the limbs should be examined, one by one, and in the same careful manner the chest, abdomen and head. In this way the injuries cannot fail to be noted. When there is dangerous hemorrhage caused by wounds, and fainting from loss of blood ensues, appropriate means to control it must be employed promptly. To arrest bleeding different methods are employed, all more or less mechanical. Pressure is the readiest and most effective means for the temporary control in urgent cases. To apply the fingers over the course of an artery and compress it sufficiently to shut off the current of blood requires but an instant, and this advantage in time is not to be overlooked, especially when a large vessel is wounded.

Troublesome bleeding from wounds in the palm of the hand is effectually checked by similar methods. Digital compression of the large arteries of the thigh is more difficult owing to the large mass of muscles by which it is surrounded. Resort must be sought in more effective methods. The limb should be elevated and a small, firm pad placed over the artery, then a handkerchief or piece of rope is made to encircle the limb over the pad, a sharp stick introduced into the loop and twisted upon itself until the bleeding is effectually controlled.

Cold is an effective means of checking oozing from small arteries or veins. Ice, snow or cold water is placed in contact wth the bleeding surface. Heat is equally serviceable, and is applied by means of compresses dipped in hot water. In deep wounds, when the source of bleeding is obscure and the condition of the patient critical, packing the wound with strips of gauze, or with absorbent cotton, is permissible. After removing blood clots the gauze or cotton is forced into the bottom of the wound, and the cavity filled and a bandage firmly applied to the parts. In these manipulations absolute cleanliness is to be insisted upon to prevent infection. The hands of the operator should be thoroughly scrubbed with soap and water and the dressings kept free from contamination with as much care as possible.

Internal bleeding, induced by serious injuries, is, unfortunately, not amenable to active treatments, and we must content ourselves with insisting upon perfect quietude, administering cool drinks, and applying cold compresses over the affected region. These simple means may appear insignificant and of doubtful utility in the presence of grave conditions, and the temptation to do something more radical

in the way of treatment is at times difficult to resist. A moment's reflection upon the indications to be met should establish the fact that the immoderate use of stimulants or active movements of the patient tend to deviate the object we have in view, viz.: to favor the formation of a clot at the point of rupture of the artery or vein —nature's method of arresting hemorrhage; fainting is a saving incident, and may be so regarded, unless the weakness is progressive and the shock so profound as to threaten immediate death. In the latter emergency, stimulation and warmth must be the treatment. It is to be understood that surgical skill is required to deal with such extreme cases. The suggestions above outlined are for the benefit of those who are uninstructed in the treatment of severe injuries. First aid applies only to the temporary care of those who are disabled and helpless; with that its utility ceases. Some injuries disable without endangering life, as instanced in the case of fractures of the limbs. Here some support is needed to steady the fragments during transportation. The resuscitation of those who have been overcome and rendered unconscious by inhalation of poisonous gases is necessarily first aid work. The question of how to accomplish this object must be considered. Little can be done before removal to a location where the air is comparatively fresh. Then cold water dashed into the face and friction applied to the limbs will stimulate the resumption of breathing. Should it fail to do so, artificial respiration must be resorted to at once. It consists of forcing air into the lungs by imitating the natural act of breathing. The steps of the procedure are as follows: Place the patient upon his back with head and shoulders slightly elevated; loosen the clothing and cleanse the mouth and nostrils; pull the tongue forward and bring it out at the angle of the mouth, to remove all obstruction to the entrance of air. The operator then kneels at the head of the patient, and, reaching forward, grasps the arms near the elbows, carries them up in an extended position. This maneuver creates a vacuum in the lungs, allowing air to enter; the arms are held in this position for two seconds, then carried downward and pressed firmly against the sides, forcing air from the lungs by compression. This to and fro movement is kept up at the rate of fourteen to fifteeen per minute, until there is a return of natural breathing, usually shown by a voluntary gasp on the part of the patient. This is the most reliable of all methods of restoring suspended animation, caused by inhaling carbonic dioxide; air must be gotten into the lungs ,either by force or natural act of breathing. Otherwise the case is hopeless. This is true for physiological reasons, which cannot be discussed here; suffice it to say that under normal conditions oxygen freely enters the blood by way of the lungs, and its presence there is essential to life. As soon, therefore, as the breathing becomes regular, the inhalation of oxygen gas may be begun and continued until the livid color of the skin becomes less marked and consciousness returns. In the absence of the oxygen gas stimulants are next to be thought of ,as soon as there is ability to swallow. Whiskey or aromatic spirits of ammonia are choice. Ammonia has the property of quicker action, but less durable than that of alcohol. Sniffing the fumes of ammonia is also useful. When patients begin to revive there is apt to be cramping of the limbs, or general convulsions. This requires no treatment beyond protecting them from injuring themselves by the convulsive movements. The cases need watching for some hours, for it may happen that those who are apparently out of danger will suffer a relapse and become again unconscious and die if left to themselves. The lifting and carrying of the injured is apt to be awkwardly done by men inexperienced in such service. Many injuries are of such a nature that misapplied force will further complicate the lesions which already exist, if indeed it does not lead to irreparable damage. A simple fracture of the leg may be converted into a compound one by injudicious handling. An unnecessary laceration of tissue is produced and consequent suffering, beside adding to the gravity of the case. This is but one of the many things which may happen to the disadvantage of the patient during transportation. To lift an injured person properly requires three bearers. Two should stand upon opposite sides in a position to support the upper part of the body, the third where he can conveniently take care of the lower extremities. Then, with the patient upon his back, all drop upon one knee, the two principal bearers, pushing their arms under the back, lock hands firmly together. The

third pushes both arms under the limbs. At a given signal all arise to their feet. The weight is thus so evenly distributed as to be easily borne, and there is no appreciable jar or sudden twisting of injured parts.

A litter devised by the writer is adapted for underground work and insures safety in whatever position it may be placed. By its use in mining accidents the difficult problem of getting those severely injured to the surface, without discomfort or danger, is satisfactorily solved. The litter, with its burden, may be put upon a cage or in a bucket, and, when fastened in appropriate position, can be brought up without disturbing the position of the patient. To the litter a rope is attached to one end, and a guy line to the other, the latter being used to steady it during transit. When the upright position cannot be maintained—owing to syncope, from loss of blood—a semi-horizontal or even reverse position may be chosen for the time being, in order to allow the remaining blood to gravitate towards the heart and brain, an expedient that is sometimes useful in extreme cases. The fastenings are so arranged that the position of the patient is not changed with reference to the litter while executing the different movements of hoisting or transporting through narrow passages, thus affording additional security and dispensing with an extra number of bearers. In practice this plan is proven an excellent one. The litter is inexpensive and durable; after being brought up to the surface the injured are given over to the care of a physician, or placed in an ambulance for conveyance to the hospital, and the duties pertaining to the first aid are practically ended.

In rendering first aid to the injured simple methods are to be preferred; they are always available and, moreover, within the comprehension of anyone possessed of ordinary intelligence, and can by them be easily put in practice at the time and place most urgently demanded.

Officious and meddlesome interference is to be avoided. It is never necessary and may do harm. There are certain definite things to be done in sudden emergencies. Common sense and prudence should indicate the course to pursue in every instance. The rule to do no harm is a good one and should be kept in mind at all times. Its observance is never a cause of regret, but, on the contrary, an evidence of a true desire to keep within the limits of safety—a most commendable qualification in the non-professional when called upon to take an active part in the care of the injured.

Hydraulic Compression of Air.*

Methods of Compressing Air by Falling Water—The Efficiency of This Method.

Probably one of the oldest applications of the use of water power to the wants of man was a form of hydraulic air compressor which operated as an entrainment apparatus. This was the well-known water bellows or trompe of the Catalan forges.

This apparatus, briefly described, consisted of a bamboo pole, disposed at a slight inclination from the perpendicular, into the upper end of which a stream of water was led, entraining air with it in its downward passage. The low end of this bamboo pole was introduced into a bag made of the skin of some animal, the air being allowed to escape from the water into the upper part of the bag, whence it was led by pipes or tuyeres to the forge, the water being allowed to escape from the lower edge of the bag. From this original device a great many improvements have been worked out, and besides this a number of other forms of hydraulic air compressors, or of compressors using other liquids for compressing air or other gases, have been designed.

One of the first inventions carrying out this idea was made by J. P. Frizell, Boston, Mass. His invention made use of an inverted syphon having a considerable horizontal run D between the two legs A and B. A stream of water was led into the upper end of the longer leg A, and at the top of the horizontal run D between the two legs of the syphon was provided an enlarged chamber C in which the air separated from the water. The water was then led off from the lower part of this air chamber and passed off through the short leg B of the syphon, the pressure of the air accumulated in the air chamber being therefore due to the height of water maintained in the shorter

* From a paper by Wm. O. Webber read before the N. E. Cotton Manufacturers' Association and reprinted in *Machinery*, to whom we are indebted for the illustrations.

leg of the syphon. This application of carrying upward the water, after the air was separated from it, so as to produce a considerable pressure upon the air, seems to have been original with Mr. Frizell, and in this feature his device differs from the old trompe.

Another device, Fig. 2, differing somewhat from that of Mr. Frizell, was invented by A. Baloche and A. Krahnass in 1885, and consisted of a syphon B carrying water from an upper to a lower reservoir, the lower end of the syphon being projected through an inverted vessel R placed nearly at the bottom of the second reservoir. Just beyond the bend of the syphon and in line with the axis

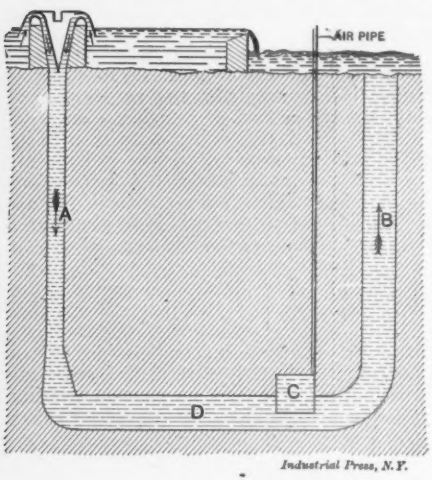


FIG. 1. FRIZELL SYSTEM.

of its longer leg, an air pipe T projected into the descending leg of the syphon. This entrained the air with the descending column and carried it down into the inverted chamber R, from which the air escaped at the top, while the water passed out from the bottom into the lower reservoir. This apparatus produced pressure on the air in the top of the inverted chamber, due to the height of the water column upon it.

Another device, Fig. 3, patented by Thomas Arthur in 1888, differs from the last in having a stream of water led directly into the top of the vertical pipe A. Inserted into the mouth of this pipe was a double cylindrical cone C forming an annular air passage between it and the walls of pipe A.

Owing to the increase in the velocity of the water in passing through the narrow throat of the double cone, air is inhaled through the pipe D, through the annular space mentioned and through perforations in the lower cone, and is entrained with the falling water.

Through the downflow pipe A rises a vertical delivery pipe Z for the compressed air having its lower end H enlarged and open at the bottom. Projecting upward into this enlarged air-delivery pipe was a water escape pipe F through which the water passed after having parted with the air. The escape pipe was in the form of an inverted syphon and maintained on the air in the delivery pipe Z a pressure due to the elevation of the water at the discharge point above the air line in the large end of the delivery pipe.

A number of other patents on apparatus of tnis type have been issued to Charles H. Taylor. His invention, Fig. 4, consisted principally of a downflow passage having an enlarged chamber at the bottom and an enlarged tank at the top. A series of small air pipes project into the mouth of the water inlet from the large chamber at the upper end of the vertically descending passage, so as to cause a number of small jets of air to be entrained by the water, Taylor seemingly having been the first to introduce the plan of dividing the air inlets into a multiplicity of smaller appertures evenly distributed over the area of the water inlet.

The first of these compressors on the Taylor principle was installed at Magog, Quebec, to furnish power for the print works of the Dominion Cotton Mills Company. The head of water is 22 feet; the downflow pipe extends downward through a vertical shaft 10 feet square in cross section and 128 feet deep. At the bottom of the shaft the compressor pipe enters a large tank, which is known as the air chamber and separator.

A series of very careful tests demonstrated that with 19.5 feet head, using 4,292 cubic feet of water per minute, was recovered the equivalent of 1,148 cubic feet of free air per minute, which would represent 248 cubic feet of air per minute compressed to 53.3 pounds pressure, showing that out of a gross water horse-power of 158.1, 111.7 horse-power of effective

work in compressing air was accomplished, giving therefor an efficiency of 71 per cent. In the tests at Magog 81 horse power was recovered, using as a motor an old Corliss engine without any changes in the valve gear; this would represent a total efficiency of work, recovered from the falling water, of 51.2 per cent.

When the compressed air was preheated to 267 degrees Fahrenheit, before being used in the engine, 111 horse-power was recovered, using 115 pounds of coke per hour, which would equal 23 horse-power. The efficiency of work recovered from the falling water and the fuel burned would be, therefore, about 61½ per cent. On the basis of Prof. Riedler's experiments, requiring only 425 cubic feet of air per brake horse-power per hour, when pre-heated to 300 degrees Fahrenheit, and used in a hot air jacketed cylinder, the total efficiency secured would have been about 87½ per cent.

In what follows will now be given an estimate of the probable efficiency of different methods of using the power of a water fall. First are tabulated the results that it is reasonable to expect when using turbines and transmitting power by belts and shafting; second by electrical transmission from generators connected to turbines; and finally by an hydraulic air compressor. The compressor, it will be seen, gives the apparently remarkable result of over 100 per cent. efficiency. This is due to pre-heating and moistening the air, however, and not to a reversal of mechanical laws.

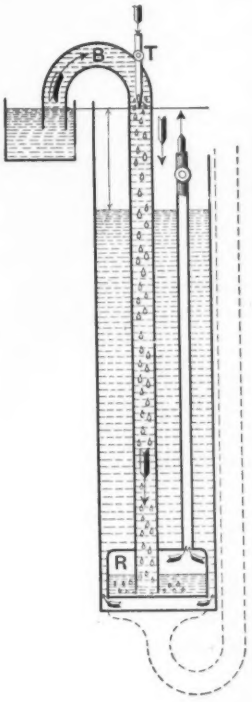


FIG. 2.

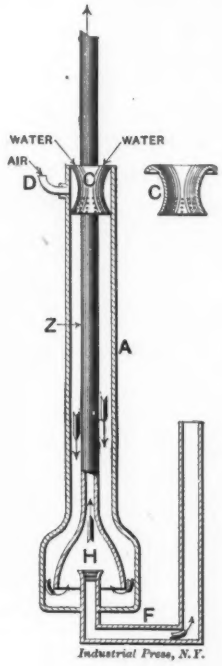


FIG. 3.

Given horse power of water....1,000 h. p.
Wheels at 85 per cent. efficiency ..... 850 "
Shafting, pulleys and belts at 80 per cent (net)..... 680 "
or a total net result of 68 per cent., wheels being at full gate and allowing the minimum loss for friction of shafting.

With wheels as usually run at part gate, the results would be as follows:
Given horse power of water...1,000 h. p.
Wheels at 75 per cent. efficiency 750 "
Shafting, pulleys and belts at 50 per cent. (average)..... 375 "
or 37½ per cent .of the whole power; both of the above being directly at the site of the water power.

and direct connected with motors at 90 per cent. efficiency..... 565 h. p.
or 56½ per cent. of the whole, or if belted at 90 per cent. efficiency ..... 508 "
say 51 per cent. of the whole.

By the use of an hydraulic air compressor:
Horse power of water.....1,000 h. p.
Hydraulic compressor at 75 per cent. efficiency ..... 750 "
Pipe line efficiency at 98 per cent. 735 "
Pre-heating dry air adds 50 per cent. .....
Moistening dry air adds 50 per cent. ..... } 1,470 "
= 100 per cent.....

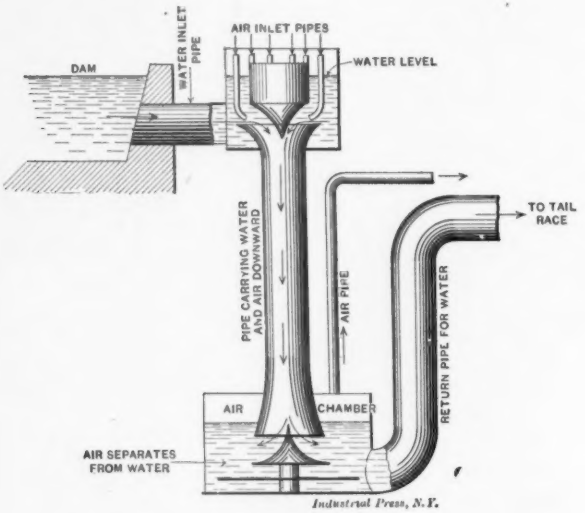


FIG. 4. TAYLOR SYSTEM.

In order to transmit power to a distance, we must take again:
Horse power of water.....1,000 h. p.
Wheels at 85 per cent. efficiency 850 "
Generators at 92 per cent. efficiency ..... 780 "
Transformers at 92 per cent. efficiency ..... 720 "
Line at 95 per cent. efficiency.. 680 "
Converters at 92 per cent. efficiency ..... 625 "
or about 62½ per cent. of the whole.

Air engines or motors at 78 per cent. efficiency .....1,145 h. p.
or 114.5 per cent.
and if belted at 90 per cent. efficiency .....1,030 "
or 103 per cent. of the whole as a resultant effect.

To estimate the efficiency of hydraulic compressing, taking into account the water absorbed by the air and the coal used in heating the air, we have the following:

The weight of a cubic foot of com-

pressed air at 85 pounds at 70 degrees Fahrenheit, equals .58.

One thousand horse power would represent 750,000 cubic feet of 85-pound air per hour; this would equal 382,000 pounds of air, and as one pound of air will absorb .58 pounds of water, we would require 221,500 pounds of water per hour. The labor represented by forcing 221,500 pounds of water per hour, equal to 3,700 per minute, against 85 pounds pressure, equals

$$\frac{195.5 \times 3700}{33{,}000}$$

195.5 feet would be ——————— equals about 22 horse power, and as pumps give an efficiency of 50 per cent., equals 44 horse power of work by pump, or 4.4 per cent. of the whole 1,000 horse power, this is therefore to be deducted: The coal used in heating the air, which is about one-half pound per horse power per hour, would also represent an amount of work equal to 75 horse power, or 7½ per cent. of the whole 1,000 horse power. This added to the 4.4 per cent. as above would equal an amount of 13 per cent. to be deducted, equals 87 per cent. of the whole horse power, or 1,030 × .87 = .896, or 89.6 per cent. as a final result of all, as against 56½ per cent. by electricity, or 68 per cent. by water wheels at their best, or 37½ per cent. by water wheels at the average.

That our results are within the bounds of reason is shown by the fact that 75 per cent. × 98 per cent. × 200 per cent. × 78 per cent. × 87 per cent. = 99.5 per cent.

Economy Derived from Reheating Compressed Air.*

The object of the experimenters in these tests was to ascertain the exact gain derived from reheating compressed air used in small motors, with the idea also that some such method as this could be advantageously put into application in connection with the use of compressed air in railroad shops, mines, etc., where compressed air is extensively used.

A small 2 horse-power vertical engine with a shaft governor was used as the motor. The compressed air coming from the compressor, was first passed through a meter, and then before being admitted to the engine, was passed through a reheater. The arrangement of the apparatus is plainly illustrated in the accompanying diagram.

The amount of air used in each run was recorded by the meter, which was furnished for the test by the Equitable Meter Company, of Pittsburg. The meter was especially designed to withstand high pressures. The air passed through the meter at the temperature of the atmosphere.

The meter was calibrated for the pressures used in the experiments, before and after the runs were made. The meter readings were then corrected from this calibration. The results therefore show accurately the amount of air used in each case.

The reheater was constructed out of pipe. It consisted of a coil of three lengths of 1¼-inch wrought iron pipe, which was surrounded by an outer casing of 6-inch pipe. This casing was also covered with an asbestos non-conducting covering, which prevented the escape of heat. The construction of the reheater is indicated in the diagram.

Gas was used for fuel, and was burned in a burner placed at the base of the reheater. Gas was selected as the fuel on account of the ease with which the supply of heat could be governed. A gas meter recorded the amount of gas used in each run. The amount of heat supplied to the reheater is then easily computed, when the heat value per cubic foot and the number of cubic feet of gas supplied per hour are known.

The engine was equipped with a Prony brake, and an indicator was attached to the cylinder, which enabled both the developed horse-power and the indicated horse-power to be computed.

In every case the temperature of the air was taken at the meter, and again after it had passed through the reheater, at a point as near to its entrance to the engine as possible.

In conducting the experiments, three series of runs were taken, as follows:

Series I., in which six runs were taken, all at about 57 pounds gauge pressure, while the temperature of the air entering the engine was varied from 60° F. to 401° F.

Series II., in which five runs were taken, all at about 82 pounds gauge pressure,

* Tests performed by W. G. Edmondson and E. L. Walker, students in the Railway Engineering department of Cornell University.

General Results—Series 1.

1	Number of run	1	2	3	4	5	6
2	Length of run, hours	1	1	1	1	1	1
3	Barometer	29.41	28.97	28.89	28.89	29.0	29.32
4	Gauge pressure at meter (corrected)	57.6	55.	55.4	57.8	58.7	58.7
5	Gauge pressure at engine	55.	53.	53.8	56.	57.	57.0
6	Temperature at meter	51.2	86.8	86.3	79.1	81.5	74.3
7	Temperature at engine	59.	176.5	256.	306.	348.	401.
8	Temperature of exhaust air	7.	87.6	147.	177.	198.	236.
9	Temperature of room	48.	79.	83.	78.	76.	70.
10	Temperature of flue in heater	—	220.	309.	352.	—	421.
11	Cubic feet of air per hour from meter	371.	319.5	300.	270.	248 5	234.
12	Cu. ft. of air per hr. corrected from calibration of meter.	377.	323.4	303.4	274.4	252.6	238.
13	Cubic feet of air per hour at standard conditions	1,877	1,445	1,367	1,295	1,204	1,150
14	Increase in temperature of air by heating	—	89.7	169.7	226.9	266.5	326.7
15	Corresponding increase in volume, per cent	—	16.4	31.0	42.0	49.4	61.1
16	Weight of air supplied per hour, pounds	143.5	110.4	104.4	99.0	92.2	87.8
17	B. T. U.'s absorbed by air per hour	2,659	2,350	4,210	5,340	5,840	6,820
18	Cubic feet of gas per hour from meter	—	9.5	16.5	22.2	—	28.8
19	Cubic feet of gas per hour, actual	—	8.7	15.7	21.4	—	28.0
20	B. T. U.'s contained in 1 cubic foot of gas	530	530	530	530	530	530
21	B. T. U.'s supplied to heater, per hour	—	4,615	8,320	11,350	—	14,840
22	Efficiency of reheater	—	51.0	50.6	47.1	—	45.9
23	Average cut off, head and crank, per cent	56.	36.5	35.	32.2	29.4	28.
24	Average ratio of expansion	1.79	2.74	2.86	3.11	3.40	3.57
25	Range of temperature of air in engine	52.	88.9	109.	129.	150.	165.
26	Revolutions per minute	330.5	363.	375.	378.9	381.5	357.5
27	Brake load, pounds	5	5	5	5	5	5
28	D. H. P.	.629	.693	.7175	.7235	.727	.682
29	I. H. P.	.909	.976	.945	.956	.910	.860
30	Mechanical efficiency, per cent	69.2	71.	75.9	75.6	79.9	79.3
31	Cubic feet of free air used per D. H. P. hour	3,030	2,085	1,901	1,790	1,658	1,688
32	Cubic feet of free air used per I. H. P. hour	2,650	1,480	1,446	1,355	1,330	1,388
33	Cubic feet of free air used per D. H. P. per min	50.5	34.75	31.75	29.86	27.7	28.15
34	Pounds of air used per D. H. P. hour	228.	159.3	145.5	137.	127.	128.9
35	Cubic feet of free air saved per D. H. P. hour	—	945	1,129	1,240	1,372	1,352
36	Gain in air saved, per cent	0	31.2	37.25	40.9	45.25	44.6
37	Equivalent H. P. from heater per hour	0	.196	258	.296	.329	.304
38	Percentage of power from heater	0	31.2	32.25	40.9	45.25	44.6
39	Heat equivalent of work done per hour, (I. H. P.)	2,315	2,485	2,450	2,436	2,320	2,190
40	Work done per lb. of air (n=1.408) adiabatic expansion, B. T. U.	9,170	5,180	5,000	4,690	4,600	4,630
41	Efficiency of the fluid, per cent	253.	48.5	49.0	51.8	50.4	47.2
42	Thermal cost of air saved per D. H. P. hr., B. T. U.	—	6,670	11,600	15,700	—	21,800
43	Thermal cost of equivalent amount of air from compressor, B. T. U.	—	131,500	15,700	172,500	191,500	188,500
44	Ratio: Cost of air by compressing / Cost of air by heating	—	19.7	13.5	11.0	—	8.62
45	Thermal cost of air from compressor in B. T. U.'s per D. H. P. hour	415,000	292,000	264,200	249,009	231,000	234,000
46	Total thermal cost of air used per D. H. P. hour	415,000	298,670	275,800	264,700	—	255,800
47	Gain in economy, per cent	—	28.1	31.2	36.3	—	38.4

General Results—Series II.

1	Number of run	1	2	3	4	5
2	Length of run, hours	1	1	1	1	1
3	Barometer	29.4	29.28	29.24	29.38	29.34
4	Gauge pressure at meter (corrected)	79.6	81.	82.	82.5	82.
5	Gauge pressure at engine	76.6	78.	79.	79.6	79.2
6	Temperature at meter	64.	63.	66.	64.2	63.
7	Temperature at engine	63.	160.5	252.5	307.5	395.
8	Temperature of exhaust air	9.	81.	146.	192.4	248.
9	Temperature of room	51	63	63	58	64
10	Temperature of flue in heater	—	213.	299.	360.	425.
11	Cubic feet of air per hour from meter	315	293	252	237	214
12	Cu. ft. of air per hr. corrected from calibration of meter.	331.5	308.5	266.	252.	226.
13	Cubic feet of air per hour at standard conditions	2,105	1,992	1,725	1,646	1,474
14	Increase in temperature of air by heating	—	96.5	186.5	243.3	332.
15	Corresponding increase in volume, per cent	—	18.5	35.5	46.5	63.5
16	Weight of air supplied per hour, pounds	161.	152.2	132.	125.7	112.8
17	B. T. U.'s absorbed by air per hour	—	3,490	5,840	7,250	8,870
18	Cubic feet of gas per hour from meter	—	13.5	19.4	22.	33.6
19	Cubic feet of gas per hour, actual	—	12.7	18.6	21.2	32.8
20	B. T. U.'s contained in 1 cubic foot of gas	—	530	530	530	530
21	B. T. U.'s supplied to heater, per hour	—	6,730	9,850	11,220	17,380
22	Efficiency of reheater, per cent	—	51.8	59.3	64.6	57.1
23	Average cut off, head and crank, per cent	30.	26.2	20.2	18.5	17.4
24	Average ratio of expansion	3.33	3.82	4.95	5.4	5.75
25	Range of temperature of air in engine	54.	79.5	106.5	115.7	147.
26	Revolutions per minute	360.	395.3	396.	403.3	396.
27	Brake load (net) pounds	5	5	5	5	5
28	D. H. P.	.685	.753	.755	.770	.755
29	I. H. P.	.999	1.11	1.027	.953	.903
30	Mechanical efficiency, per cent	68.5	67.9	78.6	.808	.835
31	Cubic feet of free air used per D. H. P. hour	3,120	2,650	2,286	2,137	1,951
32	Cubic feet of free air used per I. H. P. hour	2,110	1,800	1,682	1,725	1,632
33	Cubic feet of free air used per D. H. P. per min	52.	44.16	38.1	35.6	32.5
34	Pounds of air used per D. H. P. hour	235.	202.	175.	163.2	149.
35	Cubic feet of free air saved per D. H. P. hour (from 60 degs. F.)	10.	480.	844.	993.	11.79
36	Gain in air saved, per cent	—	15.35	27.	31.7	37.7
37	Equivalent H. P. from heater per hour	—	.1158	.204	.244	.285
38	Percentage of power from heater	—	15.35	27.	31.7	37.7
39	Heat equivalent of work done per hour, I. H. P.	2,544	2,825	2,616	2,430	2,300
40	Work done per hour by air (n= 408) adiabatic expansion, B. T. U.	8,200	7,760	6,720	6,420	5,750
41	Efficiency of fluid	31.	36.4	39.	38.8	40.
42	Thermal cost of air saved per D. H. P. hr., B. T. U.	—	8,930	13,050	14.600	23,000
43	Thermal cost of equivalent amount of air from compression	—	73,100	129,000	152,000	180,000
44	Ratio: Cost of air by compression / Cost of air by heating	—	8.2	9.88	10.4	7.84
45	Thermal cost of air from compressor in B. T. U.'s per D. H. P. hour	470,000	404,000	350,000	326,400	298,000
46	Total thermal cost of air used per D. H. P. hour	470,000	412,930	363,050	341,000	321,000
47	Gain in economy, per cent	—	10.	22.7	27.5	31.7

while the temperature of the air entering the engine was varied from 60° F. to 395° F.

Series III., in which two runs were taken at about 77 pounds gauge pressure, and the temperature of the entering air 42° F. and 266° F., respectively.

The average results from each "run," were then taken from the log of each run, and are shown on the general result sheet.

The tests were performed during the month of April, 1902, in the mechanical laboratory of Sibley College, Cornell University.

The term "cubic foot of free air" is used to represent the volume of air at standard conditions, which are taken in this case to be at a pressure of 14.7 pounds, absolute, and at a temperature of 60° F.

CONCLUSIONS.

The net gain in economy obtained with the lower pressure was 38.4 per cent., while with the higher pressure it was but 31.7 per cent. with the same conditions. In other words, we get a reduction of from 31 to 38 per cent. in the cost of the production of compressed air, by reheating the air from 60° F. to 400° F.

The curves on Plate I illustrate how the economy is raised by increasing the temperature. It is seen that the increase in economy is gradually lessened after the temperature reaches about 300° F. By continuing the curve it would indicate that the point would soon be reached where an increase in the temperature would not cause any further increase in economy, this point being reached at about 450° F.

The results obtained in these experiments afford an interesting comparison of the effects produced by different degrees of reheating, as well as by the use of different working pressures. Of the three dierent series of runs taken, the one employing the lowest pressure (56 pounds) seemed to give the most efficient results.

It was not considered advisable with our engine to raise the temperature of the entering air much above 400° F., on account of the bad effect it would have upon the packing in the valve-rod and piston-rod glands, and also upon the lubricant; however, a much higher temperature could have been attained with the reheater used.

Although the economy derived from the application of heat to the air may result from the increased volume, we are led to believe that the high results obtained

General Results—Series III.

1	Number of run..	1	2
2	Press. at meter..	76	78
3	Press. at engine.	73	75
4	Temp. at meter.	44	67
5	Temp. at engine.	42	266
6	Temp. of exhaust air	—	149.5
7	Temp. of room..	42	65
8	Temp. in flue of heater	—	—
9	Cu. ft. of air per hr. from meter.	367	249
10	Cu. ft. of air per hr. corrected from calibration of meter..	383	259
11	Cu. ft. of air per hr. at standard condition	2,430	1,606
12	Increase in temp. of air by heat'g	0	199
13	Corresponding increase in volume, per cent...	0	38.
14	Wt. of air supplied per hr., lbs.	185.6	122.7
15	Bt. T. U.'s absorbed by air per hour (from 67 degs.).....	—	5,790
16	B. T. U.'s required to raise temp. from 42 degs. F.....	—	6,500
17	Total thermal cost of air used per hour, B. T. U.	352,500	146,000
18	B. T. U.'s supplied to heater per hour (from 42 degs.)	—	13,000
19	Efficiency of reheater (assumed), per cent.....	—	50.
20	Revs. per minute.	392	396
21	Brake load.....	5	5
22	D. H. P.....	.73	.755
23	I. H. P.....	1.40	.974
24	Mechanical efficiency, per cent.	52.1	77.5
25	Cu. ft. of free air per D. H. P. hr.	3,380	2,130
26	Cu. ft. of free air per I. H. P. hr.	1,735	1,700
27	Cu. ft. of free air saved per D. H. P. hour...	—	1,200
28	Gain in air saved, per cent.....	—	36.4
29	Thermal cost of air saved per D. H. P. hour, B. T. U.....	—	13,000
30	Thermal cost of equivalent amt. of air from compressor, B.T.U.	—	174,600
31	Ratio: Cost of air by compressing. Cost of air by heating	—	13.4
32	Gain in economy, per cent.....	—	30.2

13.091 cubic feet of air at 60 degs. F. and 14.7 ft. pressure equals one pound.

are due partly to other changes of condition in the working of the engine resulting from the higher temperatures. By reheating the air the engine is relieved from the difficulties due to freezing of the moisture in the exhaust passages, and the choking up of the valve.

It was noticed that as the temperature of the air was raised while the pressure remained constant, that the speed of the engine was increased, the cut-off was made shorter, and in general the operation of the engine was rendered much more smooth.

The results appear to be approximately those that are indicated theoretically with the same conditions, and prove conclusively the many advantages to be gained by reheating, which was the object of the investigation.

For instance, it is seen that the reduction in the air consumption of a small motor is in almost direct proportion to the increase in temperature. By referring to the curves on Plate I. it is seen that the decrease in the consumption of air is in almost direct proportion to the increase in temperature, until the higher temperatures are reached, when the decrease becomes more gradual and finally ceases, when the temperature is raised above the limit of practicability.

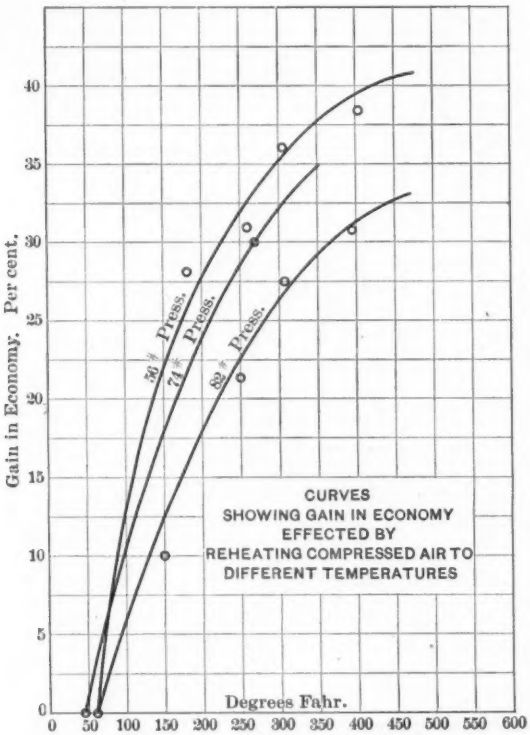


PLATE I

In Series I., which employed a pressure of about 56 pounds, it is seen that a saving of 44.6 per cent. of the air used cold was

effected by reheating it from the temperature of 59° F. to 401° F.

With Series II, and III., in which higher pressures were used, the gain was not quite as much on account of the lower efficiencies which always accompany higher pressures with compressed air.

As shown by item No. 44, on the result sheets, the results obtained by applying heat in this manner to compressed air are from eight to eighteen times more important than would be obtained if the same amount of heat were expended under the boiler back of the compressor.

The results obtained in these experiments may be represented clearly by means of a simple proportion. Referring to the results obtained in Series I., we find that the maximum gain in air saved with the highest temperature is 44 per cent. of the amount of cold air required to produce the same amount of power.

Let us assume that 100 pounds of compressed air at 60 pounds pressure are required to produce 1 horse-power per hour at 60° F. Then if we reheat this air to 400° F. we effect a saving of 44 per cent., and we will then require but $100 - 44 = 56$ pounds per horse-power hour. At this rate if we take 100 pounds of cold air and reheat it to the above temperature, the increase in the power produced will be:

$$56 : 100 :: 100 : x.$$

$$x = 178.6$$

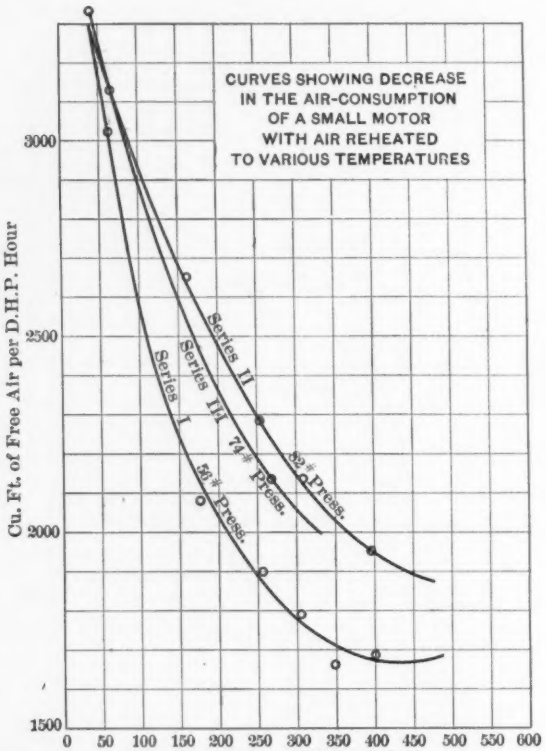


PLATE II

which indicates that the power derived from the same weight of air would be increased about 78 per cent. by reheating it from 60° F. to 400° F. In other words, a compressor which is able to supply 100 horse-power at the motor with cold air, could be made to supply 178 horse-power by the use of reheaters.

The percentages of gain given in the results refer to the developed horse-power, and the increased mechanical efficiency caused by the use of heated air must have a considerable effect upon the results. The increase in mechanical efficiency is shown by the curves on Plate III.

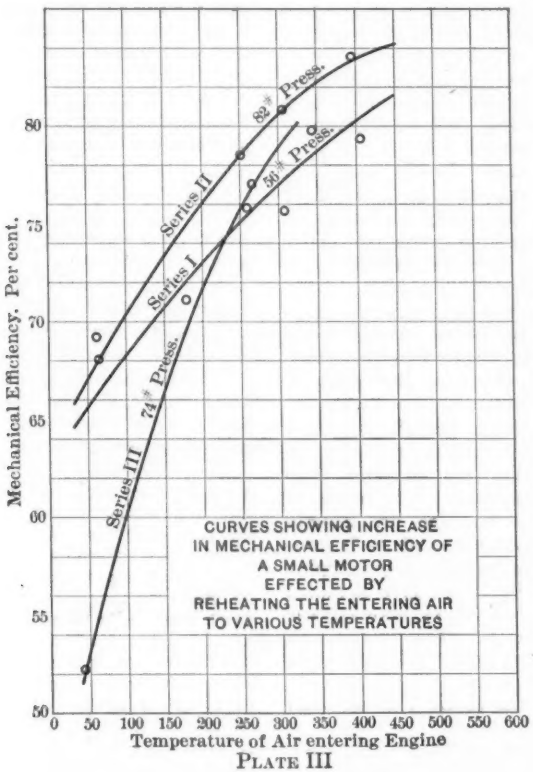


PLATE III

As the increase in volume obtained by raising the temperature of the air from this amount is only 65.3 per cent., it will be observed that the increased saving must be due partly to the more favorable conditions that the heated air provides for the engine.

Thus three important points are secured by the use of a reheater:

1. Absence of freezing.
2. Reduced cost of plant throughout.
3. Great increase in permanent economy.

—*Engineering and Mining Journal.*

Quadruplex Two-Stage Air Compressors.

A recent issue of *The Engineer* of London describes a type of stationary quadruplex two-stage air compressor, made by Reavell & Co., of Ipswich. Referring to this compressor *The Engineer* says the machine is constructed generally on the lines of the smaller air compressors, but it differs in a number of details, notably in that the air is compressed in two stages. There are other points of difference which would, we think, be of interest to our readers, and we therefore propose with the aid of the accompanying illustrations to give a full description of this interesting plant.

It is, as we have already stated, of the quadruplex type, that is, it has four cylinders, arranged radially, at equal distances round a common crank pin. It is single-acting, and has a relatively small stroke, so as to permit of a high revolution speed. This has been done so as to allow of direct connection to high-speed engines. In the particular instance which we are describing, however, the compressors, of which there are two, are not—as will be seen from the illustration—direct-coupled to the engine, but through the medium of a Hans Renold chain. The circular compressor tanks on each end of the frame of the machine are exactly similar to one another, and each constitutes a complete two-stage quadruplex compressor. In Fig. 1 we give sectional views of one of these tanks, showing the internal arrangements. The compressor tank or casing is so called because, while the cylinders are placed in it, it also affords space for inter-cooling, as we shall describe later on.

The makers inform us that they have arranged this machine for a two-stage compression for two reasons. First, because they have found that with machines of 120 to 150 cubic feet per minute capacity and upwards it is a distinct economy to go to the extra expense of performing the compression of the air in two stages, with pressures of 80 lbs. to 100 lbs. per square inch as used for pneumatic tool work.

In support of this contention they inform us that quite recently they have had to investigate a case of an American single-stage compressor of the same delivering capacity as the machine we are describing, namely, about 285 cubic feet. This machine required 55 brake horse-power when delivering this amount of air at 100 lbs. pressure. The Reavell air compressor, so the makers tell us, requires 58 indicated horse-power, and as the efficiency of the engine is 85 per cent. the power available at the engine shaft is 49 horse-power. The efficiency of the chain drive is taken at 92 per cent., leaving some 45 effective horse-power as the amount required to drive the compressor. These figures show a gain of about 20 per cent., and Messrs. Reavells assure us that this quite agrees with other figures which they have obtained. They have even found in some cases a saving of 25 per cent. by the use of two stages in large size compressors, with pressures of 100 lbs. In addition to this economy there is certainly an advantage in two-stage over single-stage machines, in that the former bring up the air pressure to the delivery point with a jerk at the end of each stroke, which the latter do not, thus causing more wear and tear in the single-stage than is experienced in two-stage machines.

The other reason is that the arrangement enables each line of parts to maintain a constant thrust upon the connecting-rod, gudgeon, and crank pin, so that silence in working is secured after considerable wear has taken place. As a matter of fact, the machine which we saw at work had been running almost continuously for several months, and we were struck with the practically complete absence of noise, either from the running parts or from the air valves. The air cylinders are 10 ins. and 5 ins. in diameter respectively, the ratio between them, therefore, being as 3 to 1, since the larger cylinder is annular in form. The piston stroke is 5 ins.

The air is admitted to the center of the tank through the openings at the end and through an automatic inlet arrangement, which can be seen in Fig. 1. This is an ingenious device, whereby the supply of air is controlled by the pressure of the air on the delivery side, so that when no air is required from the compressor the in-

let valve is automatically closed. The way this is brought about will be readily understood from Fig. 2. Here it will be seen that the inlet consists of a valve formed of two concentric rings, one fixed and the other movable, fitting closely together, and both provided with port openings. These

to a spindle, which also has attached to it a lever carrying a weight and provided with a spring. Fastened to the under side of the lever is a small piston-rod, the piston of which is inside a cylinder, the under side of which is in communication with the air delivery pipe. When the

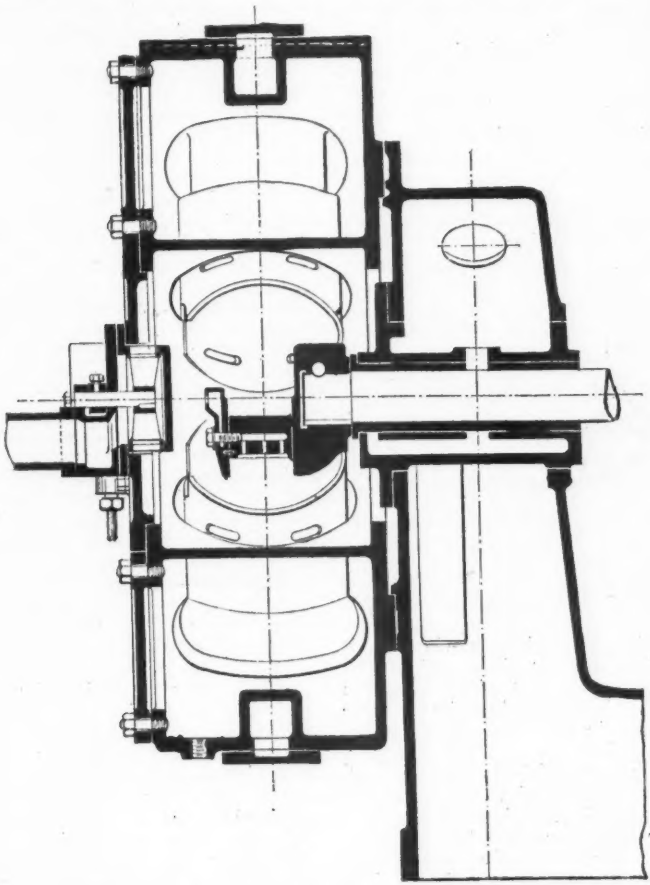


FIG. 1. THE REAVELL AIR COMPRESSOR.

are so arranged that by the revolution one way or the other of the movable ring they are either open or closed, the holes in the outer and inner ring coinciding in the one case and being covered up in the other. It is the inner ring, or piston valve as it really is, which moves. This is fixed

compressor is working normally, and the compressed air is being used for doing work, the valve is in the position shown in the figure, that is to say, the ports are open. Should, however, the demand for air cease, the pressure will at once tend to rise in the delivery pipe, and when it

has reached a certain amount the piston is lifted in the cylinder sufficiently far to cause the lever to rise, and in doing so turn the valve so as to close it. No air can then enter the compressor tank, and consequently it will be easily seen that very soon a vacuum is formed in the suction chamber, and the machine, since it is doing but little work, absorbs proportionately less power.

The governor is provided with three speed pulleys—a custom which we understand is always observed by the makers—so that the driver can set it to run within the limitations thus provided at the speed best suited to the average amount of air required for the time being. In addition to this there is a governing device on the throttle valve which acts on the same principle as that which governs the air inlet regulator already described. A small

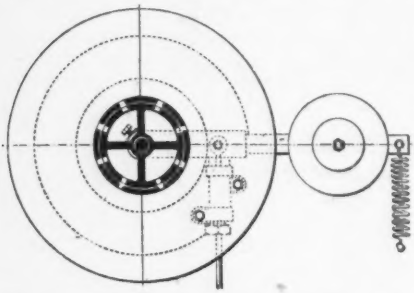


FIG. 2. AUTOMATIC AIR INLET VALVE

cylinder is in communication with the air delivery pipe, and the piston-rod of this cylinder is so connected with a lever on the throttle valve that when the pressure reaches a certain limit the throttle valve is closed, saving for a small bye-pass, which allows just sufficient steam to reach the cylinder of the engine to prevent the latter from stopping. When the air pressure in the delivery falls below the limit the throttle valve is again opened, and automatically tne engine speed is quickened. We watched the working of this apparatus on the occasion of our visit to Ipswich, where we were enabled, through the courtesy of Ransomes & Rapier, in whose works the plant is installed, to examine it carefully. The variation in air pressure was not much over one pound, and the engine and compressor were working entirely by themselves and without attention. Messrs. Ransomes & Rapier informed us that they had every reason to be satisfied with the whole apparatus, which had given practically no trouble at all, and which had been of very great assistance to them in the carrying out of the contract for the Nile Dam sluices, which contract had, largely owing to their having installed the compressor and adopted pneumatic tools, been completed well in front of time.

Turning now to a further examination of the sectional drawings, it will be seen that each of the gudgeons on the connecting rods is provided with two milled-out passages. These coincide with two ports in the piston during the suction stroke, but are blinded from these ports during the delivery stroke. Thus, during each suction stroke the air is admitted on to the top of each piston without having to pass through any suction valves, and when the piston is completing its suction stroke and the crank is turning the bottom center, the piston overruns ports cast in the side of the cylinder and allows a free communication of air from the suction chamber to the top of the piston. This is done with the object of allowing the cylinders to fill with air at atmospheric pressure without any attenuation. On the delivery stroke the air is forced through the delivery valve and passes into a receiver, or space, between each of the two cylinders of each compressor. These spaces are all inter-connected with copper pipes, thus equalizing the pressure in the different parts of the machine, these pipes being zigzagged so as to make the capacity as large as possible.

The cranks to which the compressor rods are attached are so arranged that when any one of the four low-pressure cylinders is compressing its air the opposite high-pressure cylinder is performing its suction stroke. There is, as explained, a complete connection between all the receivers, and hence the air, as it is delivered from the low-pressure cylinder on one side, has to pass completely round the tank to the opposite high-pressure cylinder, through the zig-zagged pipes, becoming cooled to normal temperature in its passage, the pipes, of course, being in a water bath. The air passes through the suction valves in the high-pressure cylinders, and on the delivery stroke is forced into a port cast round the periphery of the casing. Three sides of this

port are in contact with the cooling water in the casing or tank. The air can be taken off at any one of the four positions indicated. The valves used throughout are of the maker's special multiple type. Only one size of valve is employed in the construction of all the different sizes of these compressors, the number of separate valves employed being governed by the requirements of each size of cylinder. We drew attention to this form of valve when we described the former compressor, but we may say here that they are very thin and light, each valve weighing less than an ounce. The travel is only 1-16 in., and they work to all intents and purposes noiselessly. Indeed, when the machine is at work it is almost impossible to detect any noise from them. As each compressor has four cylinders, and as the second delivery valves open soon after half-stroke, there is nearly a continuous stream of air delivered by the machine. In the double-ended type, such as that which we are describing, the crank of one machine is set 45 degs. in advance of the crank on the other end, with the result that there are eight deliveries of air per revolution. With the machine running at 250 revolutions per minute, there are therefore 2,000 deliveries per minute, or 30 per second, and the makers claim that this continuous stream of air delivered from their machine enables a large reservoir to be dispensed with in many cases where the quantity of air required is steady and normal.

Messrs. Reavell have supplied us with a detail of a test made of this machine before it was delivered. This test, though very interesting, is too long for us to print in full; but from it we gather that at 222 revolutions per minute—the normal speed being 250 revolutions—a displacement efficiency of 91·4 per cent. was attained. This meant a piston displacement of 287 cubic feet per minute, the pressure being 93·5 lbs. above atmosphere.

Reavell & Co. are now engaged in building various plants where chain-driving and gearing is being done away with. In one case, the steam engine is being fixed directly between two compressors. This method has already been adopted with single compressors. An example of one of these is shown in the case of a compressor supplied to the war office for the cordite factory at Waltham Abbey. There is also being introduced a combination of compressors, with a slow-speed motor placed directly between them. We have had an opportunity of inspecting the arrangement of one of these machines, which was in course of construction at the time of our visit. The whole machine has only two bearings, the compressor bearings being made to serve for the motor as well. The motor is of the variable speed type, and is provided with a special form of automatic controller.—"*The Engineer*," of London.

An Air Compressor for Driving Model Engines.

The pump here described was designed expressly for the use of amateurs who make a specialty of building model steam engines. The main object kept in view was to provide a quick and ready means of supplying compressed air for driving models upon occasions when the trouble and time taken up in getting a boiler ready would not be convenient. The apparatus will also be of use for driving a "show" model, which, as fixed in its glass case, would be spoiled if handled or driven by steam in the regulation way. It would also be handy during the construction of a cylinder and piston for a model engine, when it would prove advantageous to know whether the piston was a perfect fit without escape of air.

I take it that nearly every model engineer possesses a lathe of some sort, and this air compressor is constructed so as to work off the faceplate of lathe.

Briefly, the pump consists of two cylinders and pistons worked from a crank pin on faceplate of lathe.

A reservoir is also provided, and is coupled to the ends of cylinders by means of two elbows for maintaining a constant pressure. The whole is fixed on to a base which is placed at right angles to bed of lathe, and is securely held to the bed by means of a bolt and nut.

The drawings (Fig. 1.) show the arrangement clearly enough, but perhaps a description of a few of the important details will not be amiss.

It should be borne in mind that the proportions here shown are for a lathe of 3 in. centers ,and the cylinders are 1⅛ ins. diameter, and of necessary length to permit of a 1½ in. stroke; therefore, anyone contemplating making a pump must

make the wooden base and other details to suit his own particular lathe.

The cylinders are of cast brass of about ⅛ in. thickness, with a flange at one end and a stiffening rib at the other end. A bottom flange is provided, through which four holding-down studs pass, and are screwed into the wrought iron plate, which forms part of the base of the whole. The cylinders should be accurately bored, and smoothly finished, and the flange at end should be faced up from

The elbow is a brass casting ⅛ in. thick, with flanges the same diameter as the flange on cylinder, and drilled to suit.

The reservoir, to which this elbow is attached, is made of copper tube 1⅜ in. diameter outside, and about 5-32nds in. thick. It should be well annealed and then filled with melted resin, so as to obtain a bend without a kink. When the correct length of tube is obtained, a flange the same diameter as the one in elbow must be brazed on the ends with bolt

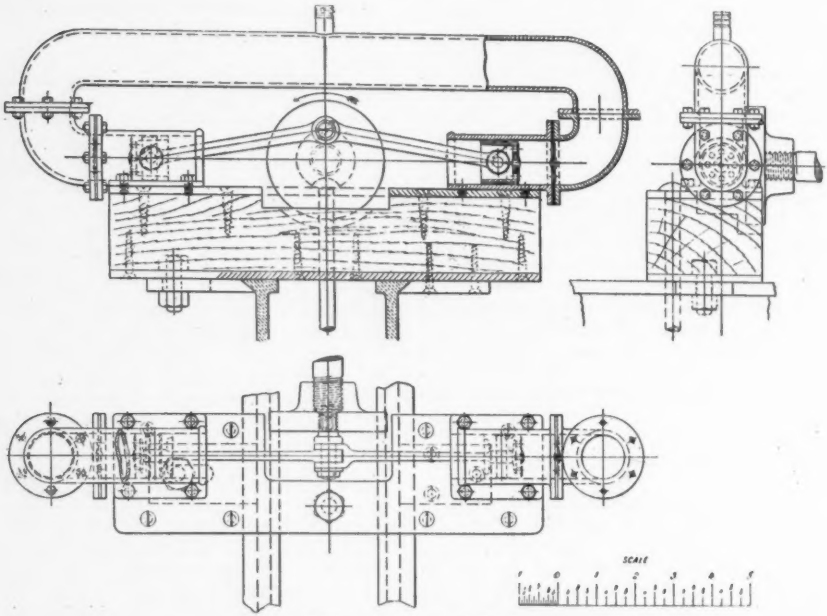


FIG. 1.—GENERAL ARRANGEMENT OF AIR COMPRESSOR.

the surface plate, so as to bolt up tightly without the necessity of packing.

Next to the end flange is the valve plate of 1-16th in. thickness brass. This should be quite flat, so as to present a smooth surface to the sheet-rubber valve, which is fastened to it by means of a copper rivet and washer.

Eight holes are drilled, as shown in the end view, for the passage of air, and six holes to take the bolts which couple up this valve plate to the flange of cylinder and also the elbow leading to reservoir.

holes in it to correspond. A short piece of tube should be brazed in the center on top of reservoir to take a flexible strong india-rubber tube to the model.

The pistons are provided with bosses on the inside, and are drilled to take steel pins for the piston rods to oscillate freely upon. The pin should be a good fit so as to be quite tight and immovable in the boss. A groove should be cut on the outside of piston to receive a well-greased leather to keep it tight. The back of the piston is drilled with eight holes in a sim-

ilar manner to the valve plate for the air inlet, and a circular disc of rubber is attached to it in the center by a rivet and washer.

The connecting rods are of steel, and one of them has a fork end as shown in plan, while the other is furnished with a solid end of such a size as to fit nicely in the fork end.

The small ends of rods in the pistons must fit between the inside bosses of pistons without side play, and are drilled to fit pin so that it shall work smoothly without any knock.

The crank pin is of steel carefully turned and is screwed in tightly to faceplate. It is provided with a collar to take up any side play of piston rods, and at the front end it has a washer fitted tightly on to it with a taper pin passing through each.

The base of all this is composed of two pieces of wrought-iron plate, about 3-16ths

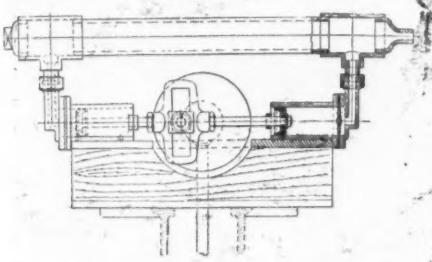


FIG. 2. ALTERNATIVE DESIGN OF AIR COMPRESSOR.

in. thick, and a hard wood block of such a depth as will suit lathe center. The plates are at the top and bottom of the wood block, and are fixed to it by countersunk wood screws.

A portion of the wood block must be recessed and the top plate cut away to allow the faceplate to stand in, also to give clearance for connecting rods. At the bottom of this base are two pieces of iron about 1½ ins. wide, one being fixed to base and the other free to move by means of a slot. These pieces of iron are necessary to prevent any play of the pump on the bedplate of the lathe, and in addition to these a holding down bolt ⅜ in. diameter, which passes right through the base and is fastened to a washer plate under bed of the lathe, should be provided.

For those who prefer a straight action, I submit an alternative arrangement (Fig. 2). The reciprocating motion is obtained through a slotted link which is coupled to a crank pin on the faceplate of lathe. In this case the pistons are tightly screwed on the piston rod, and pieces are fixed at the front end of each cylinder to act as guides. The valves are constructed in a similar manner to the one just described, and the reservoir in this case is made of ordinary gas barrel and tees. It is attached to the back of the cylinder covers by coupling nuts. The description of base for the previous arrangement applies also to this one.

The lathe should be driven in the ordinary direction—that is, towards you. The speed will, of course, depend upon the output of air, and will be controlled by the size of the model, the speed at which it is run, etc.

The great advantage of the apparatus is its cleanliness; often when one has a well-made and showy model, one is not tempted, except on rare occasions, to put steam into it.—W. E. S., in *Model Engineer and Amateur Electrician*, London.

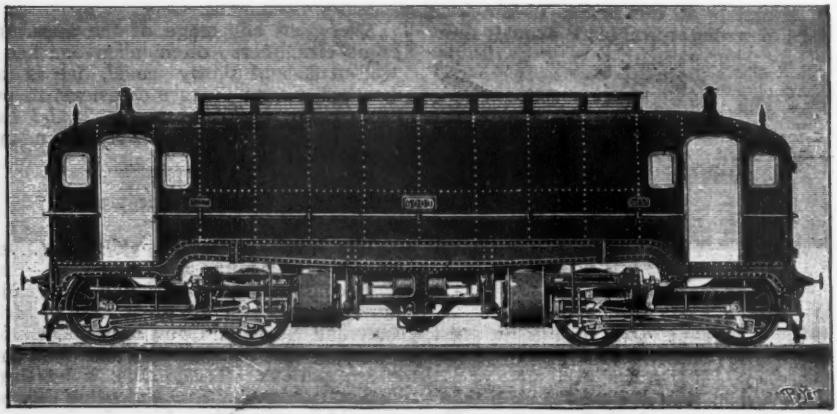
Compressed Air Locomotives.

The Invalides station, which the Compagnie des Chemins de Fer de l'Ouest has just constructed, is designed principally for the service of the great lines of Brittany and Normandy, and consequently for relieving the Saint-Lazare and Montparnasse stations. To do this, it has been necessary to establish a short line between the old junction that skirts the Seine and the Viroflay station a little beyond that of Versailles (left bank). At this place the trains will reach the main line, upon which they will be able to run in all directions. The short line, of which the part comprised between the Invalides and Meudon is already under exploitation, is established wholly for electric traction. It constitutes the first railway line in France of which the trains are currently actuated by electric motors, for we cannot consider the two miles of the Compagnie d'Orleans comprised between Orsay and Austerlitz stations as an exploitation properly so-called.

The electricity is furnished by a central station situated at Issy, and the current is led by a third rail that accompanies the line for its entire length, and upon which bear the contact shoes of the motor cars,

in order to take up the power needed. This system offers a host of advantages that we shall not enumerate here; but it presents one drawback, and that is that it causes interruptions of the conductor at the changing and crossing of tracks. Upon the main line and at the approach to the stations this is a matter of no great importance, since the speed acquired by the train easily permits of crossing switches without sensible retardation. But this is not the case in the switching about and making-up of trains at stations. Now, since the company, by reason of the contract made with the city, cannot employ steam locomotives in the interior of the Invalides station, it has had to look for a style of smokeless locomotive capable of performing yard services. It is with such an object in view that it has recently had constructed three compressed-air locomotives which theoretically fulfill all the conditions desired. These locomotives are designed likewise for aiding trains that happen to be momentarily in distress upon the line as a consequence of the interruption of the electric current. They have been constructed in such a way that they can make the round trip between the Invalides and Versailles stations without recharging. Compressed air, employed as a motive power, especially for street car propulsion, has not given very good results; so that, upon certain lines, it has become necessary to discard it; notwithstanding the existing installations, the efficiency was deplorable. With the locomotives of the Compagnie de l'Ouest the conditions are no longer the same, since the engines are not intended for use on the line. They have to make long trips only exceptionally, and are of interest merely for yard service at stations. The foregoing remarks as to the inconveniences found in regular service are, therefore, not applicable to them.

The compressed air necessary for these locomotives is produced by a small plant installed below the Esplanade des Invalides, at the level of the subterranean tracks of the new station. This plant consists of three independent groups, each formed of a synchronous triphase current electric motor, which receives a 5,000-volt current from the central station at Issy, and of a Mekarski vertical air compressor of 200 horse power, making 100 revolutions a minute, and raising to a pressure of 1,422 pounds to the square inch the air that the Compagnie de l'Ouest purchases from the Compagnie Parisienne d'Air Comprimé at a pressure of 85 pounds to the square inch. Each compressor consists of four cylinders mounted in pairs in tandem, so that the same connecting rod serves for actuating the two pistons of the same group. The two cylinders of each of these two groups do not have the same duty to perform.



A COMPRESSED AIR LOCOMOTIVE OF THE COMPAGNIE DES CHEMINS DE FER DE L'OUEST.

The upper one effects the compression of the air only in the portion situated above the piston, while the lower one acts only for that of the part comprised beneath its piston. From the viewpoint of work, then, the two cylinders of a tandem may be considered as one and the same cylinder. Let us see how the compression is effected: The lower cylinder draws in the air at 85 pounds to the square inch and compresses it to an intermediate pressure, and then sends it into a reservoir, whence it is sucked by the upper cylinder in which the compression is carried to 1,422 pounds to the square inch. In order to prevent heating of the metal, the cylinders are surrounded with jackets within which circulates a current of cold water. On another hand, water is allowed to flow likewise in the interior of the cylinders, so that the air coming from the compressor is always accompanied with humidity, and must be dried before it is used. The air thus compressed is stored up in an accumulator composed of six groups of twenty reservoirs. The locomotives, according to their requirements, come to these latter to obtain their supply of pneumatic power. The adoption of a system of compressed air accumulators, such as those above described, was indispensable, since, as we have seen, the plant is supplied by the electro-motive power of the line, and, as the locomotives are partly designed for the relief of the electric trains in cases of an arrest of current, it follows that the plant could not operate in cases of distress, and would be unable to render the services for which it was installed if it were desired to employ recently compressed air.

Each of these three groups of compressors is capable of giving 4,400 pounds of air under pressure. Let us add that the plant is arranged in such a way that it can furnish special portable boilers designed for reheating the compressed air upon the locomotives.

These locomotives are carried by two two-axled bogies. They have the form of a baggage car, provided with two cabs, one at each end, for the engineer. This arrangement does away with the necessity of turning the engine around for running in the opposite direction. The entire mechanism, which is extremely simple, is situated under the body of the engine so that it can be easily inspected, cleaned and repaired when need be.

The main part of the locomotive contains thirty-three reservoirs of compressed air, which the engineer can connect with the cylinders of the motors from either cab. The motors are two in number, and situated near each of the cabs. The air passes into an intermediate reservoir before entering the motors, each of which is provided with two cylinders placed outside of the frame of the car. The first is a high pressure one of 284 pounds to the square inch, and the second a low pressure one of 143 pounds. At its two extremities the engine is provided with special arrangements for the charging of the compressed air. It carries likewise portable steam boilers for the heating of the air.

The engineer's cabs are provided with all the apparatus necessary for operating and controlling the different parts.—For the above details we are indebted to *La Nature*.

A High Drop Test of an Elevator Safety Air Cushion.

A test of the air cushion installed at the foot of the elevator shaft in the Philadelphia City Hall tower was made on September 29, in the presence of several hundred invited guests. As most of our readers are aware, the tower of the Philadelphia City Hall attains the greatest height of any building ever erected. It is 500 feet from the pavement to the base of the statue of William Penn, which surmounts the tower. An elevator in the tower carries visitors from the upper floor of the building to a point just below the base of the Penn statue.

The test consisted in letting the regular passenger elevator car, weighing about 2,500 pounds, drop from the top of the shaft, a free fall of 290 feet, before entering the well-like chamber 75 feet in depth called the air cushion. In the car were a lighted lantern, six rats, fifty incandescent light bulbs, and several dozen eggs. A New York reporter begged for the privilege of accompanying the rats, but was refused. At 1:30 P. M. the car was cut loose, and four seconds later it shot like a flash out of sight into the air cushion. Two seconds afterward there was a cannon-like report, accompanying the escape of the suddenly compressed air through the valves. The sliding steel door of the

air cushion chamber was then drawn back, and inspection showed that while the lantern was upset, and a few of the eggs were broken, the rats were unscathed save for a bath of kerosene oil, and the incandescent bulbs were unbroken. The elevator car appeared to be uninjured. The test is a remarkable one in that the total fall, 365 feet, exceeded by 65 feet any previous test. The velocity of the car upon entering the air chamber after a free fall of 290 feet, neglecting air and guide friction, was about 136 feet a second, or nearly 93 miles an hour. A 2,500-pound car, after falling 365 feet, friction neglected, would possess 912,500 feet pounds energy; and if this energy were overcome by opposing a uniform resistance during the 75 feet of fall in the air cushion, its necessary resistance would be more than 12,000 pounds. The area of the car floor was approximately $5 \times 6 = 30$ square feet, so that the pressure upon the floor under the conditions assumed would be 400 pounds per square foot, or about 3 pounds per square inch. The maximum pressure was, of course, much greater than this, probably more than double, for the pressure starting at zero increased as the car descended until a maximum was reached. A 150-pound man under similar conditions of uniform retardation would experience an upward pressure of 720 pounds upon the soles of his feet, and probable not less than double, or say 1,500 pounds at the moment of stopping, while the pressure upon the hip joints would be about two-thirds that on the feet. A Sandow would readily sustain such a load without weakening at the hips or knees, but an ordinary man would almost surely collapse, although, of course, with injurious results by no means comparable to those that would follow a free fall of much less height. Mr. F. T. Ellithorpe, President of the Ellithorpe Safety Air Cushion Company, has himself many times dropped six stories without the least injury.

Relative to the egg as a means of testing the effect of a sudden stopping of a falling elevator car, some experiments made by a member of the *"Engineering News"* staff, and were described in their issue of July 28, 1898. It was there shown that an egg pressed between flat surfaces was crushed by a pressure of 4 1-3 pounds, which was thirty-eight times the weight of the egg. Bearing also upon this point, we are in receipt of the following letter from Mr. Charles L. Duenkel, M. E., formerly Chief Engineer of the Ellithorpe Safety Air Cushion Company, and designer of the air cushion in the Philadelphia City Hall tower:

Sirs: I have given the subject of tests of elevator air cushions recently made in a public building in Philadelphia, Pa., my careful consideration. Guided by a considerable experience as chief engineer of a local air cushion company, I feel obliged to protest against the claims for safety alleged by the placing of eggs in an elevator cage and then permitting the cage to fall and be checked by the action of the air cushion.

The conditions imposed are in no sense correlative with that of a human being falling in the cage. The degree of pressure at which an egg will rupture is about 95 times its weight when the major length of egg is set horizontal, and about 140 times its weight when its major length is set vertical. A human being can safely receive a pressure from the conditions imposed not to exceed five times his weight.

I submit for your consideration a summary of the tests made by me in the falling of elevator cages loaded with eggs to an air cushion, each egg weighing about 2 ounces.

First. The major length of egg set horizontal the result was:

1.	Crushing force,	9.66	lbs.;	77.35		
2.	"	"	13.35	"	106.8	
3.	"	"	11.49	"	91.98	
4.	"	"	14.3	"	114.4	
Total	"	"	48.80	"	390.53	times its weight.

Average crushing force per egg, 12.2 lbs., or 97.63 times its weight.

Second. The major length of the egg set vertical the result was:

1.	Crushing force,	16.79	lbs.;	134.35		
2.	"	"	14.77	"	118.2	
3.	"	"	24.63	"	197.05	
4.	"	"	16.20	"	129.60	
Total	"	"	72.39	"	579.20	times its weight.

Average crushing force per egg, 18.1 lbs., or 144.8 times its weight.

I believe the data submitted will disprove the fallacious claims for safety advanced in the test referred to, and I trust induce tests of a safer character to be imposed on the installation of air cushions.

Yours very truly,

Chas. L. Duenkel.

120 Liberty St., New York City, Oct. 2, 1902.

From the results of these tests it is quite evident that, provided no jar took place, an egg would stand a drop in an elevator car falling a distance of at least thirty-eight times the depth of the air cushion, according to *Engineering News* tests, and 95 to 145 times the depth of the air cushion, according to Mr. Duenkel's experiments, assuming a uniform retardation in the air cushion. In the 365-foot fall

in the Philadelphia City Hall tower, where the ratio of air cushion depth to total drop is about one to five, it is manifest that the few eggs which broke were broken by jar at the time the car struck the bottom, and not by pressure developed by their inertia.

While pressure developed by inertia would not crack the eggs, it would, as we have shown, cause a man to feel as if he literally weighed a ton, and might result in serious injury.

The egg test is, therefore, very unsatisfactory, as proof of the effectiveness of the air cushion as a safety device. The fall of animals in the car without injury is much more convincing, and the larger the animal the more convincing would such a test be.

So far as one could judge by the sound there was no perceptible rebound of the car when it reached the bottom of the air cushion, the air escaping through the valves preventing a rebound.

THE AIR CUSHION.

In ordinary building construction the air cushion is located in the basement, but in the Philadelphia City Hall it is suspended in the tower proper, with its base a few feet above the third story floor.

In proportioning the air cushion it has been found necessary to make its depth from 1-6 to 1-4, usually 1-5, the maximum possible drop of the elevator car. The sides of the air cushion chamber in the Philadelphia City Hall tower are of 5-16 sheet steel, stiffened with horizontal 5-inch I-beams, 19 inches c. to c. At the bottom is a heavy sliding steel door which is of course closed after the entrance of passengers into the car. There is a clearance of about ½ inch between the elevator car and the sides of the air cushion. An air escape vent is provided in one side of the air cushion, and is triangular in shape. Its base, 4 inches wide, is located at the top of the air cushion, and its vertex is 35 feet below. Fifteen feet below the vertex of the escape vent is an escape valve having a circular opening 15 inches in diameter, and 10 feet from the bottom of the air cushion is another similar escape valve. The springs of the valve, as shown in Fig. 2, are so proportioned that at a pressure of about 3 pounds per square inch on the valve surface it will begin to open, and at 9 pounds per square inch the valve will have reached its maximum opening. Near the bottom of the air cushion is a check valve which permits air to flow inward and prevents the formation of a vacuum under the car when it begins its ascent.

We would suggest that the use of the triangular opening or vent near the top of the air cushion is not mechanically correct, for at the moment that the car enters the air cushion the pressure of the enclosed air is zero, and instead of providing means for the escape of the air at that moment, it should rather be confined, in order to bring the air pressure up and begin retarding the car as quickly as possible.

The valves should then be set to blow off at a pressure that will provide for uniform retardation of the car in its passage down the air cushion and at a rate which will just suffice to bring it to a full stop when it reaches the bottom of the air cushion chamber.

Four ordinary compound elevator springs are provided at the bottom of the air cushion to act as bumpers. The springs are about 5½ inches diameter, 16 inches high, and susceptible of a 7-inch compression.

It will be evident that in case the car should fall into the air cushion from some point below the top of the shaft and the valves were the only means of escape, the car would be stopped before it reached the bottom of the air cushion, or more quickly than necessary. As actually installed, however, there is a narrow air space all round the sides of the car, between it and the walls of the chamber, and the air escapes here as well as through the air valves in case a car falls into the cushion.

The total weight of steel in the City Hall air cushion is about 120,000 pounds, and the contract price in place was $25,000.

Similar air cushions have been in use for many years in office buildings, among which may be mentioned the 20-story Empire Building, and the *World* Building in New York City; the Frick Building in Pittsburg, and the Temple Court Building in Minneapolis. Government officials are said to be contemplating putting an air cushion in the elevator shaft of the Washington Monument. The height of the monument, it may be observed, is 550 feet.

A good deal has been said for and against the air cushion as a safety device. A fair conclusion seems about as follows: An air cushion should only be regarded as

an emergency appliance, supplementary to a first-class equipment of automatic safety catches on the car. As such an emergency appliance it should prove a valuable adjunct in saving lives and limbs in case all other safety appliances fail and the car falls.

We are indebted to Mr. F. T. Ellithorpe, President of the Ellithorpe Safety Air Cushion Co., of New York, and to Mr. Charles L. Duenkel, M. E., former Chief Engineer of the same company, for courtesies and aid in securing material for this article.—*Engineering News.*

Referring to the above article, a correspondent writes *Engineering News* as follows:

Sir: I noticed the interesting account of the test of an elevator safety air cushion in the Philadelphia City Hall tower and your comments thereon. Permit me to suggest a simple method by which a real test of such a cushion may be made. The spectacular "egg test," as you well show, amounts to nothing.

Support a weight of 150 lbs. on three helical springs of such dimensions that they will be about 6 ins. high when loaded with 50 lbs. each (the static weight of the slab resting on them) and 4 ins. high when loaded with say 150 lbs. each. Place under the center of the load a cylindrical plug, sliding, with some friction, in a hole in a wooden block. Let the weight when quietly resting on the springs push the plug a short distance into the hole, and measure the distance the plug extends out of the hole. When the elevator falls and is brought to rest by the air cushion, the maximum compression of the springs will be measured by the distance the plug has been pushed in. Then by merely piling weights on top of the 150-lb. weight until the deflection of the springs equals the maximum recorder deflection, we may know what weight a 150-lb. man would have to support.

Of course this would still leave unsettled the question how many times his own weight a man can safely sustain when subjected to retardation such as that effected by the air cushion. It seems a great pity—on this and other accounts—that the yellow journal reporter who was so anxious to accompany the rats in the falling elevator car at Philadelphia the other day was not permitted to do so.

Very truly, K. W.

New York, Oct. 9, 1902.

Pumping Oil Wells by Compressed Air.*

Mr. Knapp has installed a plant for pumping and handling oil by compressed air at Chanute, Kansas. He has built a central power house, in which is a Westinghouse gas engine and an air compressor, from which compressed air is conducted to all points desired. It is believed this is the second plant in America using compressed air to pump oil, the other being at Corsicana, Texas.

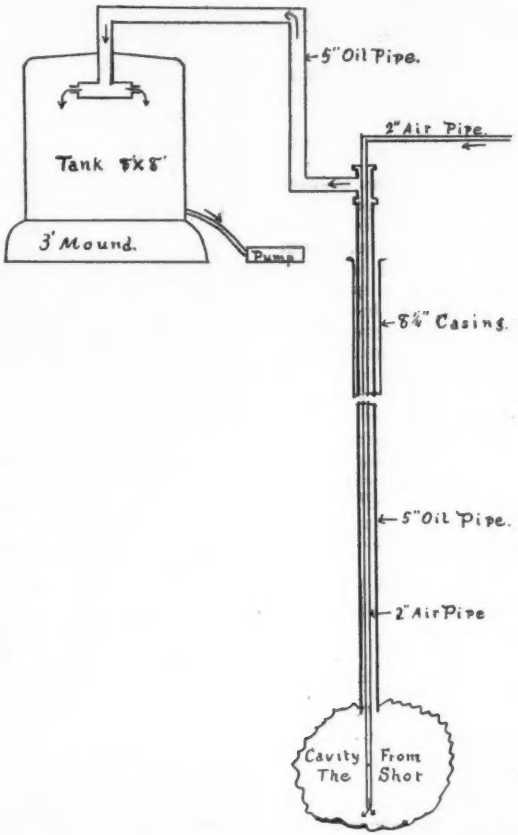
The power station is a one-story brick building, used both for power house and office. It shelters a 3-cylinder 11 by 12-inch Westinghouse gas engine of 85 horsepower capacity,and a Rand air compressor 11 by 5 by 16 inches, class D, belt driven, which, with 120 revolutions per minute, has a capacity of 210 cubic feet free air per minute raised to a pressure of 350 pounds, requiring from 65 to 70 horsepower to operate it. The excess power of the gas engine over that required for the air compressor is used in part to pump oil from the large tank into the oil cars, and in part for pipe threading and as a matter of safety.

The compressed air is conducted through 2-inch pipes all over the oil field. It is used to blow oil out of the wells, and also to run the pumps for pumping oil from the small local tanks into the larger tank near the power house. The arrangement at each well is the same, and consists of a small oil tank 8 feet high and 8 feet in diameter, with a capacity of about 70 barrels, connected with the well and pump by a system of pipes, as shown in the illustration. In drilling a well, an 8-inch casing about 25 feet long is used to shut off surface water. Inside this a 6-inch casing is put down 200 feet or more and afterward withdrawn. Lastly, a 5-inch casing is put in, which goes down 600 feet and which remains as long as the life of the well continues. At the upper end of the 5-inch casing a 5-inch T is screwed on, from which a 5-inch conduit leads to the tank. Through an opening in the top cap the 2-inch air pipe enters and passes down to the bottom of the well, as is also shown. When valves are properly opened compressed air escapes at the lower end of the 2-inch pipe and literally blows the oil out through the 5-inch pipe and into the tank. The tank is placed on a little mound of earth about 3 feet high, partially to guard against damage from flood water, but principally to let gravity feed oil from the tank into the pump near by. A 2-inch pipe is inserted at the bottom of the tank, which leads to a small pump and ultimately to the large storing tank.

* Abstract of an article in the *Engineering and Mining Journal*, Oct. 11, 1902.

The pipe carrying compressed air likewise leads to the same pump, supplying power for running it.

Wells producing but 2 or 3 barrels per days are blown once every 24 hours, while those producing 20 to 30 barrels are blown 6 times every 24 hours, experience having



DETAILS OF OIL WELL PUMPED BY COMPRESSED AIR.

shown that more frequent blowing does not increase the production. Ordinarily the air pressure used is about 300 pounds, but it frequently runs down to 250 pounds. A Bristol recording pressure gauge is used, which automatically produces a continuous record.

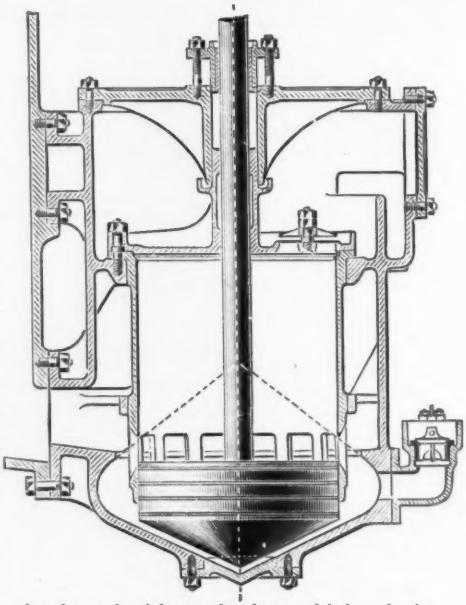
The large central tank is 50 feet in diameter and 40 feet high, with a capacity of 14,000 barrels. It is situated in the angle between the Missouri, Kansas & Texas and the Santa Fe railroads. Near by, on each line, are the loading tracks, where five oil cars may be stationed at a time. A 3-inch pipe leads from the large tank to each loading rack, and is so arranged that oil flows directly from the tank into the car. The racks of the Missouri, Kansas & Texas are on lower ground than the tank, so that loading is done by gravity, but those on the Santa Fe are on higher ground, loading being done by pumping.

The Chanute fields are interesting in a number of ways:

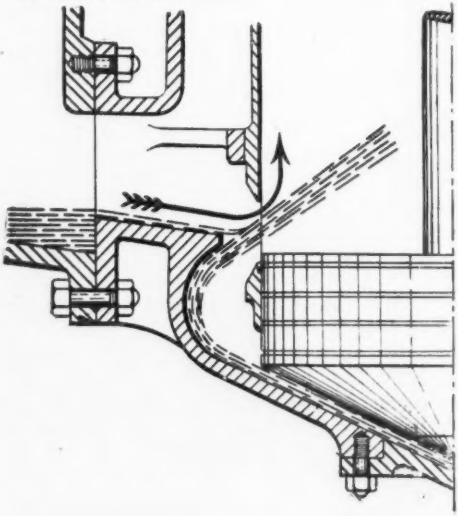
1. It is now known to a certainty that the oil and gas bearing sands are not very uniform, and not continuous over the entire area. A number of instances are known like the following: Three wells, 500 feet apart, are in a straight line. The two extremes are producers, showing a good amount of oil sand; the middle one, only 500 feet from each of the others, is a failure, showing practically no oil sand. In other instances the oil sand is entirely missing, but the lower gas sand is present, yielding large quantities of gas, and in two cases no oil nor gas sand was found at all.

2. In the Chanute field the gas bearing sands uniformly lie below the oil sands, and are separated from them by about 40 feet of shale. This is so different from conditions previously observed in other oil and gas regions that it is quite remarkable. Similar conditions have been reported from other Kansas areas, but probably nowhere else in the State are they so well shown. Here, in quite a number of instances, a fair oil producer has been changed into a gas producer by drilling through the 40 feet of separating shale.

3. The Chanute field was pronounced a failure by the first prospectors, which resulted in the territory lying idle for a number of years. It is so spotted that here and there are barren areas. Unfortunately, the first few wells were in those places. How many other good localities in the State have been similarly abandoned cannot be known at present.



lently and without shock at a high velocity through the ports into the working barrel. The rising water is followed by the rising bucket, which closes the ports, and, sweeping the air and water before it, discharges them through the valves at the top of the barrel.



The Edwards Air Pump.

The Edwards air pumps are of a unique construction. It will be seen from the illustrations that this type of air pump uses no inlet valves, either in the suction chambers or in the pistons, this form of air pump being known as the suction valveless type, the only valves being in the discharge plates, where they are readily accessible. In the action of the Edwards pump, the condensed steam flows continuously by gravity from the condenser into the base of the pump, and is there dealt with mechanically by the conical bucket working in connection with a base of similar shape. Upon the descent of the bucket the water is projected si-

In this pump the speed of the water corresponds to the speed of the bucket, and the pump, having a small and regular quantity of water to deal with at each revolution, is designed to work at high speeds.

In the design of these pumps clear air inlets are maintained through the mechanism, as herewith shown. In the Edwards pump the question of satisfactorily dealing with the air is considered as of primary importance. Under ordinary working conditions, when the bucket descends and the ports open, there is no obstruction between the condenser and the pump and the air has a free entrance into the barrel, while immediately afterward the water is injected into the barrel at a high velocity, the intent being that instead of obstructing the entrance of the air, the water tends to compress that already in the barrel, and to entrain or carry in more air with it.

The Wheeler Condenser & Engineering Co. of New York, for whom Chas. C. Moore & Co. are the Pacific coast agents, control the sole rights to manufacture these pumps in America. Chas. C. Moore & Co. say they have put in a large number of these pumps in plants lately constructed on the Pacific coast, and that the results are satisfactory throughout.—*Mining and Scientific Press.*

A New Trap for Compressed Air Mines.

In the case of air mains of any considerable length, or those exposed to sudden or considerable changes of temperature, it has been found desirable, and in many cases necessary, to provide for the accumulation of moisture condensed from the air.

Among the devices employed for this purpose may be mentioned the Flinn Differential Trap, manufactured by Richard J. Flinn, of West Roxbury, Mass., shown in plan and elevation by Fig. 1.

The operation of the Flinn trap is as follows:

Water of condensation enters at the upper opening of the ball and following the surface of the ball-shaped opening, passes between the outer and inner pipes and into the receiving chamber below the diaphragm. This column of water acting on the under side of the diaphragm forces the valve to its seat against the counter pressure of the spring. Any additional water which now flows to the trap passes through the inner pipe into the chamber on the upper side of the diaphragm. When the column of water reaches about midway the height of the pipes, the effect of this column of water, plus the pressure of the spring, balances

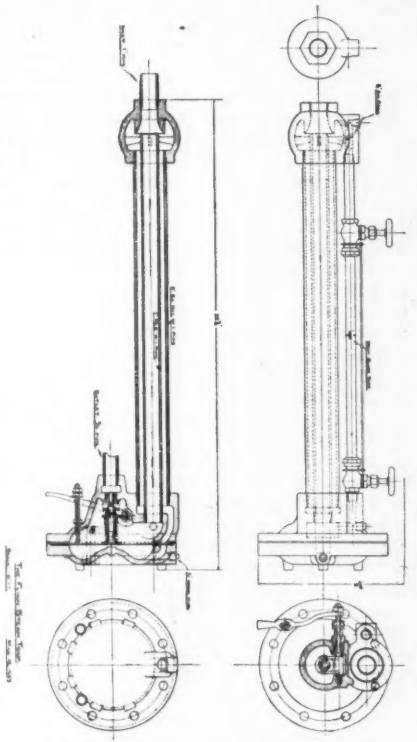


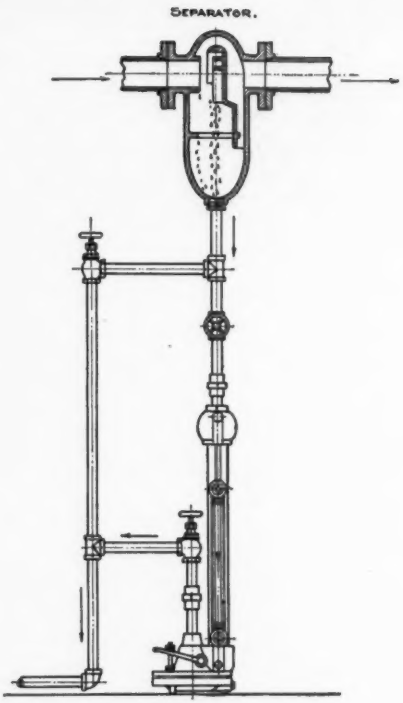
FIG. 1. PLAN AND ELEVATION OF FLINN TRAP.

the effect of the column of water between the pipes on the under side of the diaphragm. Any further increase in the height of water in the inner pipe causes a depression of the valve, which allows the water to escape until the column has fallen to a level a little below the middle of the pipe, when the valve closes again. This action is repeated at intervals, according to the quantity of water entering the pipe. So long as the water keeps coming in, in sufficiently large quantities, the

valve remains wide open. The valve acts every time the water rises above the water seal line and every time it falls below it. As stated before, this water seal line is about midway the height of the pipes. The diaphragm is not affected by the working pressure—whether one pound or 200 pounds—as there is the same pressure on both sides, top and bottom. There are but three working or moving parts: the spring, diaphragm and valve itself.

The Flinn trap opens freely for water and closes tight before the air can be blown out. It handles water at any temperature and responds instantly without readjustment for any pressure from 0 to 200 pounds. The valve of this trap is either wide open or tightly shut. This prevents wire drawing, which cuts the valve seats. The trap works by the weight of the water, which enters the inlet pipe of the trap. The first water that comes to the trap water seals it; the very next ounce of water opens the valve. The valve stays wide open if the water keeps on coming, but the valve closes instantly after discharging to its water seal level. It is claimed that the operation is just the same as instantaneous, and as reliable, with pressures of one pound, fifty pounds or two hundred pounds, and that the temperature of the water may be as high as 400 degrees.

In operation the valve, when only a small quantity of water is coming, does not merely part from its seat and stay there, but, instead, opens to its limit and stays there only so long as the water entering the trap is sufficient to hold valve open. Its action, therefore, gives an intermittent discharge when the trap is giving small or variable quantities of water, and a steady flow when the quantity is large or whenever there are sudden flushes. This feature, that of a valve which always makes a positive movement, when the time for opening comes, is one of the most valuable a trap can possess. In nearly every other trap on the market the valves opens according to the quantity of water entering, and, in consequence, the wire-drawing that takes place, it is claimed, quickly cuts the valve faces and seats. This trap will work against any back pressure less than the pressure in the trap or will discharge to a higher level than the trap, that is, to a height of about two feet for every pound of pressure carried. The special construction with one pipe inside another allows the water to impinge directly on the upper side of the diaphragm so that a copious flow of water will by its impact open the valve wide and relieve the trap immediately. The trap has a very large capacity and is built for pressures up to 240 lbs. per square inch.



THE FLINN TRAP CONNECTED TO A SEPARATOR FOR DRAINING COMPRESSED AIR MAINS.

THE BY-PASS PIPING ALLOWS THE SEPARATOR TO BE BLOWN OUT INDEPENDENTLY OF THE TRAP AND ALSO ALLOWS THE TRAP TO BE EASILY REMOVED FOR EXAMINATION.

FIG. 2.

The lever shown in the cut is for outside adjustment of the spring. It also serves to open the valve for blowing out the trap. This is sometimes necessary when grit and dirt comes from the air lines and gets under the valve. By depressing the outside lever the valve is thrown wide open and trap can be blown out.

For draining air lines, the trap should be arranged with separator something like the sketch, Fig. 2. This separator can be made out of piping or can be bought from any of the dealers in steam fittings who carry these separators for steam, which are equally good for compressed air. The Flinn Differential Steam Trap attached to these separators works automatically to drain off moisture and water which collects in these air lines.

Letters by Tube.

The network of gas pipes, electric wires, water mains, and other underground services, which lie buried beneath the London streets, may soon be added to by a pneumatic letter tube, which will whiz letters from post office to post office at a rate of forty miles an hour.

The pneumatic tube system is not a new idea, for it was in 1853 that the first tube for delivering messages was constructed in London, and the General Post Office is today connected by tubes with all the sub-post offices.

These tubes, however, are but two-and-a-quarter inches in diameter and never more than three, and they are used only for the transmission of telegrams and messages.

Our up-to-date cousins across the Atlantic long ago recognized the advantages of the introduction of the system on a larger scale, and while the British postal authorities have been dallying with the idea they have for several years had it in actual operation in New York, Philadelphia and Boston.

During its last session Congress voted $800,000 per annum, or £160,000, for the extension of an 8-in. tube system to all the principal cities, and a few days ago the American Government, which had invited tenders from several inventors, gave the award to the Batcheller Pneumatic Tube Company.

While the United States has thus been pressing forward, the British Government has been merely negotiating, and the matter is still "under consideration" at St. Martin's, although there is some hope under the new Postmaster-General of a definite step in the matter being taken.

The latest proposal made by the Batcheller Pneumatic Tube Company to the British Postal authorities is to construct an 8-in. tube from the G. P. O. to the branch at Mount Pleasant as an experiment, and let it to the authorities.

The London representative of the company yesterday explained the system to an *Express* representative.

"The time has come," he said, "when a tube service in London would not only simplify the problems of the Postmaster, but would effect a large saving.

"One great advantage to the business community would be that letters could be posted much later and be received much sooner.

"The sending and receiving apparatus are very simple, and 8-in. tubes or 12-in. tubes are at present in use. The mail matter is contained in metal carriers, which are shot through the tube by pneumatic force, a matter of a few seconds only being employed, as against the slow transmission by mail-carts.

"We know how difficult it is here for mail-carts to travel quickly through the congested streets, especially in the city.

"It makes no difference to the working of our system whether the tubes turn corners, describe circles, or go up or down inclines.

"It has been found that nearly 70 per cent. of the parcels sent through the post office are small enough to be projected through an 8-in. tube, while, by using a 12-in. tube, 90 per cent. of the goods sent out by the large shops and stores could be delivered in the same way.

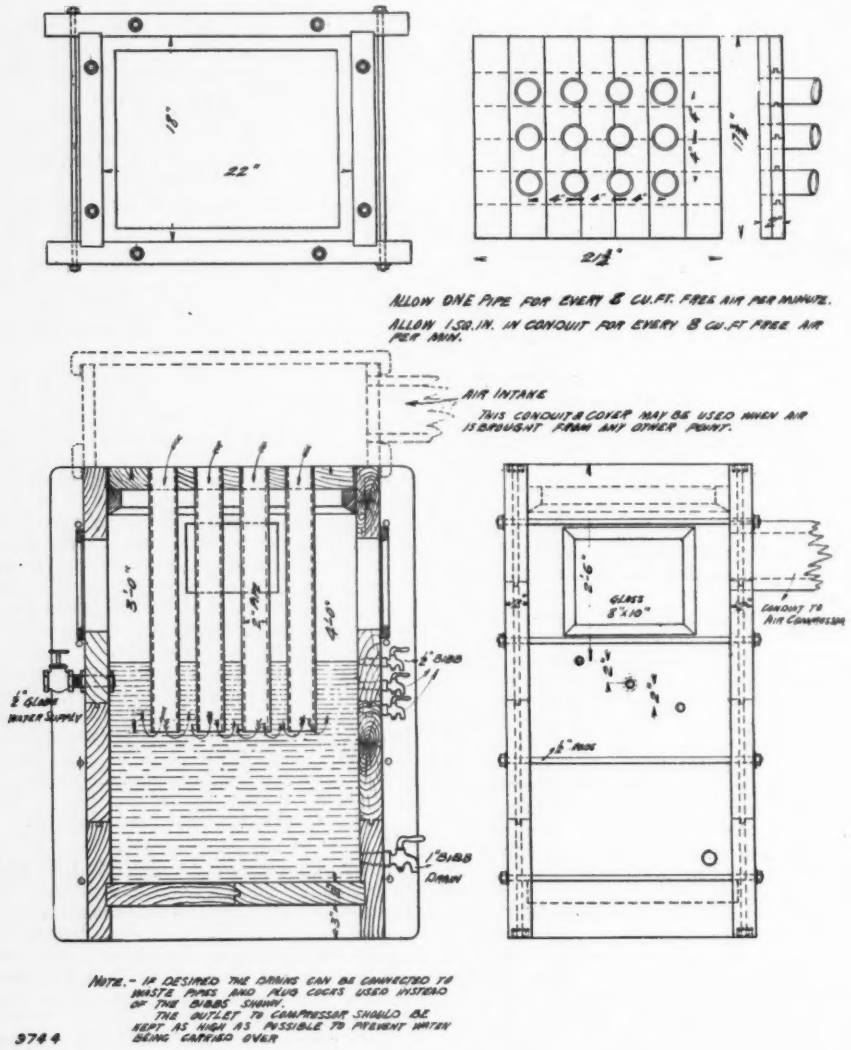
"The German Government are now arranging for the introduction of the system in Berlin, and no doubt other cities will follow suit after a time."—*Daily Express*, London.

Air Washer for Compressor Inlets.

Air compressors are frequently installed in places where a great deal of dust is present in the air, and is, consequently, drawn into the air cylinder, where it mixes with the lubricating oil in the cylinder and forms a gum which sticks the valves, causing excessive wear of valves, piston and glands.

The surest cure for this is to use an ounce of prevention and locate the compressor where there is no dust, or the inlet pipe can be run to the outside, where clean air can be obtained. In many cases this cannot be done, and it is necessary to

provide some means of removing the dust and cleaning the air. We illustrate herewith a simple device intended for this purpose which, so far as we know, has given very good satisfaction.


18"
22"
2½"
ALLOW ONE PIPE FOR EVERY 8 CU.FT. FREE AIR PER MINUTE.
ALLOW 1.50 IN. IN CONDUIT FOR EVERY 8 CU.FT FREE AIR PER MIN.
AIR INTAKE
THIS CONDUIT & COVER MAY BE USED WHEN AIR IS BROUGHT FROM ANY OTHER POINT.
3'-0"
4'-0"
GLASS 8"x10"
CONDUIT TO AIR COMPRESSOR
¾" BIBB
¾" GLOBE WATER SUPPLY
1" BIBB DRAIN
NOTE.- IF DESIRED THE DRAINS CAN BE CONNECTED TO WASTE PIPES AND PLUG COCKS USED INSTEAD OF THE BIBBS SHOWN.
THE OUTLET TO COMPRESSOR SHOULD BE KEPT AS HIGH AS POSSIBLE TO PREVENT WATER BEING CARRIED OVER
9744

Referring to the cut, it will be noticed that this air washer, as it is called, consists of a tank built of wood and provided with glass windows and three pet cocks at the side like a boiler to determine the water level. There are also suitable water supply and drain taps. The

tank has a series of tubes inserted in its top, which tubes project down into the water, and must have at least 20 per cent. greater total area than the inlet to the compressor to reduce the velocity of the entering air. Over the top of the tubes, and forming part of the washer, is a chamber which is connected with the outside air. The inlet of the compressor is connected to one side of the upper part of the box just above the water. In operation the air is drawn into the upper box and down through the tube, and bubbles up through the water into the space above the water. From there it passes into the compressor inlet. In this way all the air must come in contact with water, and all dust, lint and grease is retained by the water. The air, therefore, enters the compressor clean and free from anything which can increase the friction of the wearing parts or clog the valves or air discharge passages.

The washer should be drained and cleaned from time to time to prevent accumulation of dirt.

This device is simple, and we believe that the illustration given herewith is so complete that any of our readers will be able to construct a washer if they are experiencing trouble from dust.

We are indebted to The Ingersoll-Sergeant Drill Co. for the material from which this description was prepared.

Oils and Lubrication.

We cannot too strongly insist on the use of the best grade of air cylinder oil for lubricating air cylinders. Cheap or poor grades always contain light oils, such as gasolene and benzine, which volatilize at the temperatures frequently encountered in the air cylinders, especially in the case of simple compression to 100 pounds. Such oils also contain residue, which collects about the valve or in the discharge passages and intereferes with the proper operation of the compressor. Where oils are used which volatilize easily the gas formed collects in the discharge pipe and receiver, and when mixed wth the air coming from the cylinder and contained in the receiver forms an explosive mixture under pressure and at a temperature which requires only a slight increase to cause spontaneous ignition, and a more or less serious explosion results. Such explosions rarely occur, but unfortunately are usually accompanied by injury to the operator and damage to the machinery, and they can usually be traced to poor oil and lack of care in cleaning.

In any case, even with the best grades of oil, care should be taken to feed very little oil to the air cylinder, and after the compressor is adjusted and working smoothly previous to beginning regular service, the air cylinder lubricators should be adjusted to feed regularly. The amount of oil will depend upon circumstances, but range from one drop in three minutes to a drop each minute, according to the size of the compressor and the speed at which it is operating.

The cylinder lubricators should always be closed the minute the compressor is shut down to prevent oil accumulating in the cylinder. These should also be cleaned frequently and carefully looked after to insure proper operation.

In addition to using only a small quantity of oil, lubricators, cylinder, valve and discharge passages should be cleaned thoroughly to remove any accumulation of oil or deposited residue. Probably the best method for this is to fill the oil cup or lubricator with a rich soap and solution with proportions about one part soft soap to fifteen parts of water instead of oil, and run the compressor in the usual way, feeding the solution liberally for perhaps two or three hours; then open the receiver blow-off and drain off the accumulation of oil and water. To prevent rusting, let the soap suds feed out of the lubricator, fill cups with oil, adjust to feed properly and continue to run the compressor until the soap suds water has worked out and the compressor is again running with oil. This cleaning process should be repeated from time to time, the interval depending on the service of the compressor. If running at full capacity for twenty-four hours per day, about once every week or two will be sufficient. If on light load and running for ten hours per day once every month or two will do. In any case blow off your receiver frequently.

Baldwin Pneumatic Bench Vibrator.

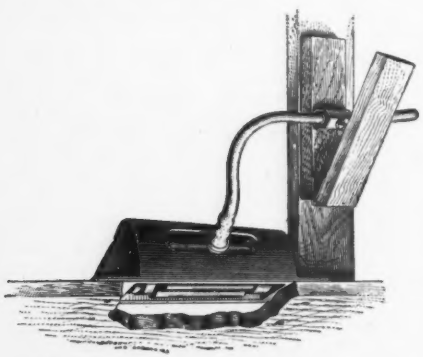
Have you ever thought how much time is lost by using two bench moulders to draw a pattern? This time is saved by using a Baldwin Bench Vibrator.

In the old way, when the moulder is ready to lift off his cope, he calls his partner, waits for him to come and rap on the bench after he has finished the work in hand.

In the new way, when the moulder is ready, he presses his knee against the valve opener, gets a much better vibration and lifts off cope with absolutely no waste of time.

This invention is of very simple construction and the only care it requires is a little oil to keep the piston from rusting.

It consists of a pneumatic vibrator in a cage connected by rubber hose with a valve which is opened by pressure of moulder's knee. The case is screwed to under-side of bench, or if bench is very



rigid, to a board laid on top of bench and the valve attached to one of the bench legs, or any other convenient place.

Experience has shown that a much more efficient vibration is obtained by placing the vibrator loosely in a cage than by attaching it to the bench itself.

As the vibrator is not attached to the pattern, no expense or loss of time is incurred in changing from one job to another and it gives equally good results, whether one or more patterns are in the flask. It also saves rapping through the cope in many cases.

As the amount of compressed air required is very small, an inexpensive air plant, run either by present steam or electric power, can be used, if a compressor is not already installed.

Notes.

Mr. W. C. Stephens, the patentee and manufacturer of the "Climax" and "Climax Vixen" rock drills, has left Cornwall for South Africa to look after his large interests in the Transvaal.

Pneumatic tubes are proposed for carrying mail between Paris and Berlin. A letter dropped in a box in Paris can be delivered in Berlin in an hour, sometimes in 30 minutes.

Theodore F. Faass, of Utica, has been appointed as foreman and mechanical repairman of the compressed air plant at Hoffmans, for the New York Central Railroad.

Bright, chatty and attractive literature continues to arrive from the Chicago Pneumatic Tool Company, and we believe that Circular No. 30, and also the pamphlet illustrating and describing the Pneumatic Hoist, which have lately been sent us, are especially worthy of notice and mention.

In Chicago the West Park boulevards will be sprinkled by compressed air. The park board yesterday decided to allow a St. Louis company to make a test of the method. The system is used in St. Louis and New York, and is said to be a success. Not only will the boulevards be sprinkled, but they will also be thoroughly flushed and cleansed.

Col. Jay H. Northup has let the contract for the establishment of a compressed air plant of large capacity for the Torchlight mines, the machinery to be delivered by November 1st. These mines are on the Big Sandy branch of the Chesapeake and Ohio Railway, five miles east of Louisa. The mines have heretofore been operated by hand.

A. W. Maconochie, member of the English Parliament and business associate of Sir Thomas Lipton, arrived a few days ago on the *Fuerst Bismarck* from Southampton. Mr. Maconochie is chairman of the board of directors of the Consolidated Pneumatic Tool Company of Great Britain, which, in turn, is owned by the Chicago Pneumatic Tool Company, and his visit to this coun-

try is to inspect the company's works in the West, preparatory to the building of a large plant by the company in Scotland.

Compressed air would seem to be dangerous when it is not skilfully used. That, at all events, must be the reflection of a switchman on a Californian train who was coupling two carriages. He picked up the compressed air pipe to attach it to the car, but before he finished the air was turned on and the blast struck him in the mouth. As soon as he recovered from his surprise he found that three upper and three lower teeth had disappeared, as if by magic, and they were blown down his throat.

At the recent meeting of the Western Pennsylvania Central Mining Institute, Mr. B. F. Jones read an exhaustive paper on the different methods of mine haulage. He discussed the advantages and disadvantages of mule haulage, locomotive haulage (steam, electric and compressed air), and rope haulage. Each method, he showed, has some peculiar feature that especially fits it for certain conditions. Nothing but a careful study of each case as it presents itself can determine what system is best to use.

The Dominion Compressed Air Dustless House Cleaning Company, of Montreal, Canada, has been incorporated to carry on the business of employment of cleaning, renovating, deodorizing and disinfecting carpets, tapestry, furniture, fabrics, hotels, hospitals, clubs, theatres, churches, stores, residences and other buildings; capital, $99,500. John S. Thurman, St. Louis; John Bryce Kay, John Irvine Davidson, Thomas Craik Irving, John Taunton King, Watson Telfer Bradshaw, Henry Winnett, Douglas Kay Ridout, John Dawson Montgomery, Toronto, are named incorporators.

While it is known that air can be made solid as well as liquid, up to the present comparatively few experiments have been made in this direction. A scientist recently converted a certain quantity of liquid air into a small solid mass, and on examining it found it was as transparent as clear ice and as elastic as rubber. To test its elasticity he struck it with a hammer, and the latter immediately rebounded. That solid air may prove to be of commercial value is the opinion of some scientists in Germany, but it is admitted that many more experiments will have to be made before any certainty on this point can be arrived at.

A 16 and 12x18 compressor, if in good condition, should be capable of operating three 2¾-inch drills or two 3¼-inch drills with 80 pounds air pressure. A 6 and 6x6 air compressor is not large enough to run any drill, as the capacity would be only about 25 cubic feet of free air per minute. This calculation is based on the three 2¾-inch drills using 260 cubic feet of free air per minute, or two 3¼-inch drills using 252 cubic feet of free air per minute. To calculate the free air capacity of the compressor, multiply the effective area of the air piston in square feet by the piston speed in feet per minute, which, in this case, is about 270, based on a speed of 120 revolutions per minute.

The Philadelphia Pneumatic Tool Company states that its anticipations in regard to the volume of business for the month of September were fully realized, the sales for that month having amounted to 20 per cent. more than any previous month. During the current month the monthly record for foreign shipments has already been broken, large orders having been received from Great Britain, Germany, France, Italy and Denmark.

Mr. Chas. G. Eckstein, the German representative of the Philadelphia Pneumatic Tool Company, arrived in New York on the 17th inst., and will probably remain some weeks in this country.

N. A. Christensen, the founder and general superintendent of the Christensen Engineering Company, has resigned his position with the company, and will hereafter devote his time to the manufacture of patent air compressors which he recently patented. Mr. Christensen retains his stock in the engineering company and will be connected wth the firm in the position of consulting engineer. A few months ago Mr. Christensen conceived the idea for a new compressor which could be used to advantage in oil wells, and after securing the patents on them decided to manufacture them himself rather than form a new company or turn the rights over to the old company.

Report comes from Cleveland, Ohio, that in attempting to take to pieces the air compressor which is used in connection with the new Holly engine for the high service district reservoir, employees at the Division street station broke some of the vital parts so that it could not be used. The pump could not, of course, be used without the air compressor, and all further attempts to supply the high service district direct with water were abandoned for the time being. The engineers and experts connected with the Holly Manufacturing Company, the makers of the mammoth engine, improved their time by going over the machinery and adjusting it for the final test, which will be made in a few days.

Herr Kruger, of Berlin, Germany, director of the company which has been formed to exploit Professor von Linde's process of applying liquid air for cooling purposes, was summoned to Hubertusstock recently to explain the principle to the Kaiser and Kaiserin. Experiments which were conducted during lunch convinced their Majesties of the extreme practicability and usefulness of the new process not only for cooling the atmosphere of large buildings but for domestic purposes, and it will be used in future in the Imperial household. Liquid air is easily transportable, and Her Majesty was specially interested in experiments showing how much more advantageous and convenient it will be in hospitals and similar institutions than the customary ice.

The work of some twenty housemaids in sweeping and dusting will be done in a twinkling in Judge Seaman's courtroom at Milwaukee, Wis., when the suit of the American Compressed Air Cleaning Company, of Milwaukee, against the Wisconsin Compressed Air House Cleaning Company, a subsidiary company of the General Compressed Air House Cleaning Company, of St. Louis, will come up for trial. The plaintiffs claim infringement on a patent originally held by Enoch Nation of Indianapolis in 1893. The basement of the Federal building is now filled wth machinery necessary as exhibits in the case, and it is probable that compressed air will be pumped from the basement to the courtroom to demonstrate the operation of the cleaner over which the contest wages.

We are glad to learn that the leaders of the Rand industry have no intention of waiting for the compulsion of legislation before taking in hand the terrible scourge of phthisis which afflicts the mine-workers, owing to the dust from the percussive drills. Prizes (the first £500 and a gold medal) are offered by the Chamber of Mines for the best suggestions and devices for combating the cause of the disease. Mr. Francis Fox suggests to a contemporary the use of the Brandt hydraulic drill, which is being found so efficacious in the Simplon Tunnel work; but as Mr. Fox himself suggests that it might possibly not be suited for employment in stoping, and as the scarce water supply has also to be taken into consideration, the Johannesburg Chamber's competition appears desirable.

The Chicago & Sonora Mining Company, which has a very rich gold property near San Antonio de la Huerta, and has obtained handsome results from a small prospecting mill during the prosecution of development work, has now had built and ready for shipment a new 20-stamp mill air compressor, tramway, and other machinery which will be set up and put into operation as soon as possible after arrival. Wagon roads, pumping plant and pipe line are already complete and ready for operation. Large reserves of ore have been exposed by the development work, and there is sufficient in sight to run for a long time such a mill as the new one ordered, the capacity of which will be increased as development progresses. Dr. R. C. Coy, of Chicago, is president of the company.

Something new in rock drilling for deep holes is reported from Frankfort, Germany, where Howarth and Walski have a device for utilizing the flushing water instead of the boring rod to convey motive power to the borer, the boring being done by a hydraulic motor attached to the bottom of the rods, water under pressure being forced through the hollow rod to the motor, the escaping water doing the flushing. The engineers mentioned say that with a drive pipe and piston 2 inches in diameter and a working pressure of 170 pounds, the test motor gave twelve strokes per second, consuming 1.1 gallons of water, and that the 8-inch bit drilled through hard standstone at the rate of 26 inches per hour; in soft sandstone at the rate of 23 feet per hour.

Three handsome catalogues have been received from the Gardner Governor Company of Quincy, Ill. Their air compressors are driven by belt, electric motor or steam. The duplex air compressor consists practically of two straight line machines placed side by side upon one bed plate and coupled to one crank shaft with one fly wheel for both. Their duplex steam pumps are built in a wide line of sizes and patterns, adapted to almost every service. Their standard Class A governor is of the gravity action, and has an automatic safety stop and speeder. It is made in sizes from 1¼ to 16 inches, and is especially adapted to the larger type of stationary engines. The centrifugal force of the balls is opposed by the resistance of a weighted lever, and the speed is varied by the position of this weight on the lever.

To measure the difference of height between two places with a barometer, first measure the air pressure, P, at the lower station, and then the air pressure, p, at the upper station. Calling T the measured temperature Fahrenheit, the vertical distance in feet between the two sections

$$= (60{,}360 + [T-32°]\ 122.68) \log \frac{P}{p}.$$

If one has a pattern made of soft pine put together with nails, an iron casting made from it will weigh 16 pounds to every pound of the pattern. If the casting is of brass it will be 18 pounds to every pound of the pattern. A metal that will expand in cooling is made up of nine parts lead ,two parts antimony and one part bismuth. This alloy is of practical value in filling holes in castings.

The pneumatic tube service between the Brooklyn and Manhattan Post Offices and between the Manhattan office and several sub-stations has been resumed. The first few batches of letters which were sent across the bridge were heavier than the tube is supposed to handle, and there was some delay resulting. The men who were operating the service are not yet thoroughly familiar with it, and did not know the exact capacity of the cases.

The mails were handled much faster than at any time for a year. After the first few loads of letters had been sent across the men learned the game and the cases arrived very fast. A special delivery letter which was mailed uptown in Manhattan, addressed to a law firm in Fulton street, near Borough Hall, was delivered exactly twelve minutes after it was posted.

A correspondent writes to the editor of the *American Machinist*: "A mandrel 3-16 inch in diameter and 120 feet long is unusual, yet that is just what I saw recently at the Boyer plant of the Chicago Pneumatic Tool Company, spinning away merrily at the rate of several thousand revolutions per minute.

"This mandrel is used for coiling the piano wire closed springs which are used instead of belts to drive the Boyer speed recorder, and it is rotated by means of an air drill at one end, while the other end runs in a bearing attached to a post. An ordinary wooden clamp, faced with hard fiber, held in the operator's hands, governs the feed of the piano wire and hence the closeness of the coil; and, to the lover of physics, not the least interesting feature of the operation is the manner in which the long, thin mandrel is thrown into loops and nodes during its rapid rotation."

We give below a letter written to *Engineering News* and the editor's reply.

Dear Sir: We would like very much to learn something of the process of blowing cement into the sand of river beds for the purpose of solidifying the same. Will you kindly give us some information on the subject?

Yours truly,
Beardsley Construction Co.,
By R. C. Beardsley.

Elkhart, Ind., Oct. 4, 1902.

[We are able to give no information relative to a pneumatic process of forcing cement into quicksand. Possibly our correspondent has in mind the Harris process of pumping cement grout into quicksand. This process was patented by the late Robert L. Harris, M. Am. Soc. C. E. (patent No. 464,771, Dec. 8, 1891), and was described in our issues of Apr. 28, 1892, and June 28, 1894. The process consists of (1) sinking pipes into the quicksand; (2) pumping out the sand so as to leave a chamber, and (3) forcing cement grout into the chamber, so that a hard cemented floor is produced. If any of our readers know of any process of forcing cement into quicksand by air pressure we shall be pleased to hear from them.—ED.]

Chicago's City Council have been asked to give a franchise, the passage of which has already been taken for granted and a contract entered into with the Government on that presumption. The Illinois Pneumatic Service Company wants the franchise in order to lay pneumatic tubes beneath the surface of the streets, and that

company, which is a branch of the American Penumatic Tube Company, a $15,000,000 corporation of Boston, was awarded by the Government on September 27 last a contract for carrying the mails by air pressure through tubes which are still in the air.

Aware that the Council will not pass again an ordinance like that of the Illinois Telephone & Telegraph Company's, free from any limitation as to the size of the tubes which can be put under the streets, the company in its request for an ordinance agrees that its tubes shall not exceed fifteen inches in diameter. For compensation the company proposes to pay the city 3 per cent. of its gross receipts for five years and 5 per cent. for the remaining twenty of the twenty-five years for which it asks that the franchise be granted.

The Chicago Pneumatic Tool Company report that owing to the vast amount of business they are receiving from the Southwest territory, they have deemed it advisable to again place a representative in that district, and therefore have located their Mr. W. C. Walker in St. Louis, with headquarters at 325 Lincoln Trust Building. They believe this arrangement will greatly facilitate handling the volume of business received from that territory, and will be very advantageous to both themselves and their numerous customers.

The most valuable feature of the gas engine manufactured by the Westinghouse Machine Company is its ability to start at a moment's notice without even the preliminary "warming up" which is required for steam engines of large size. This is accomplished by means of compressed air, which is stored in a steel tank for this purpose. One cylinder is momentarily isolated for utilization as a compressed air motor by which the engine is given a few turns. It then enters upon regular four-cycle operation, and the starting cylinder being converted to a power cylinder, full load may be at once applied. These starting operations may be completed within half a minute after the starting signal is given, and it is immaterial whether the engine to be put in service is entirely cold or has been but recently shut down.

The board of naval experts appointed to investigate the value of oil as a fuel for American warships recommends that one-third of the torpedo boats and destroyers now in commission shall be fitted with oil-burning plant. It is reported that the engineering difficulties have almost been solved. The commercial obstacles are due to the lack of oil supply in some parts of the world. The high cost remains to be solved.

The board reports that oil is practicable for use in torpedo-boats, army transports, and naval auxiliaries which cruise between points where the oil supply is plentiful. It has been tried on a torpedo-boat with good results. The problem of safe stowage, without danger from explosion of the oil fumes, which, mixed with the gases from cooking-galleys, is like gunpowder, is the great difficulty to the introduction of oil fuel into warships. The board states that most of the experiments have heretofore failed because it was attempted to burn the oil instead of atomising it with a compressed air spray.

On October 15, at Scranton, Pa., Alton F Clark, Conrad Lutz, Louis Conrad and W. M. Bingham, constituting the Correspondence Institute of America, were arrested there at the instance of Post Office Inspector Hugh Gorman, charged with a fraudulent use of the mails. They were taken before United States Commissioner Searle and held in $1,000 bail each for a further hearing.

The Correspondence Institute of America must not be counfounded with the International Correspondence Schools of Scranton. The Correspondence Institute of America was a heavy advertiser. It spent thousands of dollars in informing the people through the leading newspapers what it proposed to do, and it advertised to give instruction by mail in journalism, electricity, stenography, art illustrating, and advertising writing. Inspector Gorman says he has discovered that the concern did not possess facilities and instructors to carry out their promises.

The *Scientific American* describes two arrangements invented by Mr. W. B. Heyburn, Wallace, Idaho, to prevent the telescoping of trains in collisions. One is to so construct a guard on both the locomotive and the rear end of the train, that derailment can be substituted for the crushing of trains, and as a protection against disastrous results, such as throwing a train down a steep embankment, the second

arrangement has been devised. The guard is provided with a V-shaped impact surface, and the guard on the locomotive is capable of adjustment to the one side or the other. Normally this pilot or guard will be held, by strong coil springs, with its point midway of the track. A cylinder on the locomotive, which is shown in section, is provided with a piston connected to an arm on the pilot. This piston may be operated by steam, but will preferably be operated from the compressed air system of tne train. Suitable connections are provided, whereby the engineer may admit the compressed air to one side or the other of the piston-head, so that in event of an impending collision he may quickly swing tne pilot to one side or the other, thus choosing the most favorable side for the derailment.

The air used between the cylinders of a compound pump can be interheated by inserting an ordinary feed water heater into the suction or discharge line through which the water is pumped, the cold exhaust air passing through this heater on its way to the low pressure cylinders in the same manner as boiler feed water. Exhaust air is often several degrees below zero, and as compared with that temperature, mine water at 60 degrees is effective as a means of heating. Under this system there is no freezing and the air consumption is cut in two. This may be carried into triple or quadruple expansion for large plants of heavy duty. A hoisting engine can be arranged for reheating very readily, but in all cases the heater must be placed as close as possible to the cylinders using the air. The heater should be carefully covered with magnesia and all hot pipe connections and cylinders using the air fully protected. The usual reheating temperature does not exceed 350 degrees, a temperature that gives no trouble with lubrication, stuffing boxes, etc. The usual rule is not to heat to a point higher than will result in the exhaust being at mine temperature, thus in no way interfering with comfort or ventilation. The exhaust of a rock drill on a hot day may be below zero, though the air be used full stroke and without expansion; but with the air heated to a point which results in an exhaust temperature about equal to the atmosphere that 95 per cent. efficiency may be secured. With a small amount of heat the results are often six times more important than results from the same amount of fuel burned in a boiler furnace.

Transformers are almost double in permissible output by the simple application of an air blast to carry away the heat that would otherwise be imprisoned in the casing. Why cannot the principle be applied with advantage to railway motors, especially those intended for heavy traction? The large increase in motor capacity obtained by leaving the cases opened, a device permissible in elevated work, is well-known. Why not carry the matter a little farther and force the air through with a blower? This device would at once change the load limit from a temperature limit to one of commutation, efficiency and similar considerations, and would possibly have the effect of making the present hour rating a continuous one, which in interurban work is a consummation devoutly to be wished. The increased life of the windings and the absolutely tight casing also offer advantages which in themselves quite counteract the disadvantage of maintaining the little motor and blower which would be necessary. A further consideration, with reference to the device, is rather radical, but nevertheless attractive. Taking a 200 h. p. equipment, a fair interurban figure, working at a net efficiency of 60 per cent., counting the use of resistance in control, it is safe to say that of the 40 per cent. losses one-half could be absorbed by the air of the blower system. Twenty per cent. of 200 h. p. is 29.84 kws., or about the energy absorbed by five ordinary sets of car heaters. It looks as if the heaters would pay for the motor, blower and piping. To keep the motors and resistance cool, the passengers warm, and save the entire heater current by the process, sounds too good to be true. Of course motors do not always run at full load, and these figures require shaving, but they can withstand the process.

As to the energy for the blower motor every particle of it will appear as heat in the car atmosphere. The energy consumed in arc headlight resistance is not only ample but available for such a motor. An electric car is rather a wasteful combination after all.

Since the cheapening of air-compressing machinery, the Tilghman's sand blast process for cutting hard substances, sharpening

files, and removing the scale from iron and steel plates, forgings, castings, etc., preparatory to galvanizing, tinning, enamelling, painting, etc., has come largely into use, its superiority over the older processes of planing, grinding, pickling and galvanizing, etc., being obvious, involving as it does the minimum of loss of material and retaining the strength of metals intact. With the several designs of machines, devised for special purposes, placed on the market by Tilghman's Patent Sand Blast Co., Ltd., Broadheath, Manchester, it is even possible now to adapt it to an increasingly wide range of industries beyond those of metal, and glass working, gold and silver smithery, stone, slate and granite cutting and carving, brick, tile and pottery manufacture, and photography and block-printing are all alike benefited by its services. In the machines devised by this firm, portability and adaptability are the keynotes, and they are so made that they can be taken to the work and not the work brought to them. The designs include the sand blast apparatus with a flexible blast pipe for cleaning castings, etc., which requires a separate room for its operation, the blast pipe being directed by the hand of the operator; the complete sand-blast plant, wth automatic sand elevator and dust separator, consisting of an air compressor, receiver, sand blast apparatus with cyclone separator and valves, auxiliary cyclone separator, exhauster, air-washing arrangement, and sand-blast room, the compressor being driven by belt or steam—a plant which has received the most extended use in a variety of industries; the rotary table sand-blast apparatus for cleaning castings of flat shape; the improved sand-blast tumbling barrel, with automatic sand elevator and sand and dust separator, for cleaning small castings, stampings, etc.; and the continuous sand-blast tumbling barrel, in both which the articles are treated within the barrel, a method which renders the process entirely free from dust. The general utilities of these appliances indicate a wide field of employment for them in the mining areas of South Africa.

The cleaning of the railway passenger coach is a problem which the companies find serious in case of blockades. Last winter during one of the heavy snow storms many trains were unable to leave on schedule time from this city, owing to the fact that time had to be taken after the arrival of the delayed trains to give the car cleaners an opportunity to do their work. In the South the railways in some places use compressed air, which is quick and thorough. At the end of the cleaning tracks there is a large tank where the air is stored, and it is conveyed to the place needed through a rubber hose. The method of application is rather interesting. The air emerges from the nozzle, not in a round stream as in a watering hose, but through a device known technically as the comb. It is an elongated orifice several inches long, out of which the air emerges in a jet perhaps a thirty-second of an inch in width. It is not employed every time a car is to be cleaned, but only occasionally, being so effective that the alternate overhaulings are little more than sweepings and dustings off.

It takes four men to clean each car, two inside and two out. The former take all the seats down or move them around so as to be approached at all points, dust and wipe them off, or, if the occasion demands it, beat them with rods, or again apply the air. Every bit of the woodwork is wiped, and if looking dim is oiled and polished with waste. The brasswork is similarly treated, and is not left until its brightness is mirror-like and its surface immaculate. The outside men have not been idle meanwhile. If the day has been rainy the water hose has been brought into play, and the car is given a bath until its cuticle, if such a term may be thus employed, is without stain. Then it is wiped dry, and every now and then is rubbed off with a preparation similar to the pomade used to clean the brass, only that it is more fluid. Down below the under men have been at work on the facings of the journals and the casings of the axle boxes, and pretty soon the whole car is clean. The inspector comes along, passes on the work; the waterman mounts the roof with his pipe, fills the tanks with drinking water; the gas man attaches his hose to cocks placed at regular intervals along the track, loads up the gas tanks under each car, and it is ready for another trip whithersoever the will of the yardmaster shall designate.

An important experiment in a pneumatic sewer system which for several years past has been in operation on the Continent was recently inaugurated at the little village of Stansted, in Essex, England.

Stansted is the first place in this country in which the system—the Liernur—has been installed, and its introduction is in the nature of an experiment by means of which it is hoped by the promotors of Liernur's English Syndicate, Limited, to convince the Local Government Board of its utility.

Stansted is situated in a very hilly district, and has given the local authority considerable trouble in connection with its drainage. The new system drains by suction, and the pipes can therefore follow the contour of the ground, no incline being necessary. No man-holes are required, and flushing or ventilating columns are unnecessary.

It therefore appealed strongly to the Stansted District Council, and they decided to adopt it. The Local Government Board would not, however, sanction a loan for the system until they had seen it in operation for two years. With the object of introducing it into this country the syndicate have borne the whole of the cost of laying down the installation, and are working it for two years on the understanding that if at the end of that time it gives satisfaction the Stansted Council will take it over at cost price, otherwise the syndicate loses its money.

About a third of the householders have voluntarily connected their houses with the new installation, and over a mile of piping has been laid.

A large party attended the opening ceremony, including Sir James Blyth, Sir John Cockburn, Mr. Dobbs, Agent-General for Tasmania, and many eminent engineers. Mr. Liernur, the inventor, was present, and acted as guide.

In the pumping house, which is situated in a large meadow, is a receiver with a capacity of 3,000 gallons. By means of a vacuum pump the sewage is brought by a violent suction through four-inch instead of the usual fifteen-inch pipes.

The suction is at the rate of 6,000 gallons per hour, and the entire sewage of the village can be drawn into the pumping houses in a few minutes, leaving the pipes clean and dry.

So far, the Liernur system has been in use for some years in Trouville, the French watering-place, in the greater part of Amsterdam, in St. Petersburg, and in several German and Dutch towns.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Editor COMPRESSED AIR:

In the March number of COMPRESSED AIR I notice a water trap for compressed air mains described. Mr. Covell says that at the bottom of the separator is a ¾ in. safety valve set to trip when water reaches height of fifteen or twenty inches, thereby discharging water.

This will act all right when the pressure in the separator is constant, but should the air pressure increase two or three pounds this increase in pressure, which is equivalent to head of water of four to six feet, would be sufficient to open wide the safety valve, discharging all the water in lower part of separator, and blowing a large quantity of air through the safety valve until the pressure dropped sufficiently to allow the safety valve to seat again. You will readily see this is a wasteful proceeding, as in most machine and boiler shops where compressed air is used for operating the tools and machines, the pressure fluctuates often as much as ten pounds and a trap of this kind would, therefore, waste a large amount of compressed air. The Flinn trap will work the same under any pressure and will not allow the air to blow through no matter where the trap is located or what pressure or temperature under which it works.

RICHARD J. FLINN.

October 8th, 1902.

Editor of COMPRESSED AIR:

DEAR SIR—We have been reading your journal with great interest. We have fixed a good many permanent air lift installations and have made a good many tests in this country. Should you desire to have particulars we shall be very pleased to furnish you with same.

There is one little matter we notice in your article on "Compressed Air in Bored Well," page 1959, September, 1902, issue, wherein you say, "The various tools and plant employed are made by Messrs. J. Warner & Co." As a matter of fact, we bored the wells for the

Tunbridge Wells Corporation, and all tools were made by ourselves, as we are makers of boring tools. We should be glad if you would notify this through your paper. We put down four bore-holes for the Tunbridge Wells Corporation at Pembury, and it was at out instigation that the compressed air installation was adopted. We are now doing some further work for them.

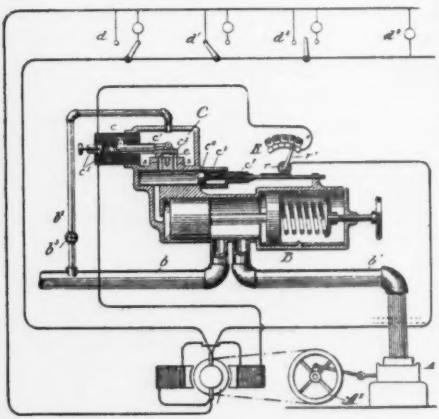
Trusting this little matter will receive your kind attention, we remain,

Yours faithfully,
Messrs. C. ISLER & Co.,
Bear Lane,
Southwark, England.

U.S. PATENTS GRANTED SEPT. 1902

Specially prepared for COMPRESSED AIR.

708,026. ELECTRIC CONTROLLER. William H. Clarke, New York, N. Y. Filed Oct. 11, 1901. Serial No. 78,317.



An electric regulator, the combination of a motor, a differential piston controlling the motor, a generator operated by said motor, an electric circuit connected therewith, a rheostat in said circuit, and means governed by the differential piston and rheostat for maintaining a constant speed of the motor.

708,027. AERO-STEAM ENGINE. Severinus J. Corrigan, St. Paul, Minn. Filed Sept. 3, 1901. Serial No. 74,055.

The combination in an engine in which four strokes of the piston and two revolutions of the crank-shaft are comprised in a working cycle, of a cylinder, a piston contained therein, a connected crank-shaft, an air-chamber, heating means therefor, and valves interposed between said air-chamber and piston-cylinder said parts being so arranged and connected that air is compressed by the piston from atmospheric pressure and temperature into said air-chamber and the clearance-space of the cylinder, during the latter half of the second stroke of the cycle, retained in said chamber and heated therein during the third and fourth strokes of the cycle, and expanded from said chamber into the cylinder during the first stroke of the following cycle.

708,092. AIR-BRAKE VALVE. Frederick Strattner, Salisbury, Md. Filed Oct. 15, 1901. Serial No. 78,742.

In air-brake apparatus, an air-cylinder and its piston for applying the brake, an air-storage cylinder and its piston arranged for simultaneous coaction with the first-referred-to piston, for releasing the brake, and air-pressure valve mechanism operatively connected to the train-pipe and to said cylinders, comprising a primary valve and an automatic supplemental valve carried by, and independently operative of, said primary valve.

708,308. GAS AND AIR MIXER. Stephan Broichgans, Milwaukee, Wis., assignor to the Perfect Gas Machine Company, Milwaukee, Wis., a Corporation of Wisconsin. Filed Dec. 30, 1901. Serial No. 87,784.

The combination of a mixing-chamber having a gas-inlet port, a mixed air and gas eduction port, and an air-inlet port, the latter adapted to deliver air to said mixing-chamber, a float within the chamber, means for suspending the float, a pivoted lever within the mixing-chamber, a connection between the float and the lever, whereby said lever is turned on its fulcrum when the float is moved, a valve for controlling the air-inlet port, and a connection between the valve and the lever, whereby the movement of the lever causes the valve to be moved away from or toward its seat.

708,408. COMBINED LIFTING-JACK AND AIR-PUMP. Joseph G. Schmidt and William P. Mueller, Milwaukee, Wis., assignors of one-third to Charles P. Herrmann, Milwaukee, Wis. Filed Oct. 25, 1901. Serial No. 79,927.

An upright air-pump having a hollow piston stem and an attachment in the form of a shank vertically adjustable in said stem.

An upright air-pump having a head-bracket, a hollow lever-controlled piston-stem, a retractive spring-controlled pawl carried with said piston-stem for the engagement of a rack-toothed shank engageable with said bracket and stem to be vertically adjustable therein, a shank-detent in connection with the aforesaid bracket, and means for holding the pawl in retracted position.

708,552. SUBMARINE OR OTHER GUN. John P. Holland, Newark, N. J., assignor to Electric Boat Company, a Corporation of New Jersey. Filed Sept. 13, 1898. Renewed Feb. 10, 1902. Serial No. 93,451.

A gun for discharging a torpedo or other projectile, having means for first setting the projectile in motion with compressed air, having regulable, mechanical connecting means between the projectile and an igniter for afterward igniting an explosive charge when the projectile shall have traveled far enough to act forcibly on the igniter through said connecting means, and having a special, stationary chamber for the explosive charge independent of the projectile.

708,669. APPARATUS FOR RAISING LIQUIDS BY MEANS OF STEAM OR COMPRESSED AIR. Albert Scholl, Mannheim, Germany. Filed Jan. 27, 1902. Serial No. 91,487.

The combination of a pressure vessel having a compressed-air space at its upper part and inlets for liquid and compressed fluid and an outlet for the liquid to be raised, a stand-pipe extending into said vessel and in communication with said air-space, a valve in said compressed-fluid inlet, a valve-plate rigidly connected with said valve and adapted to close communication between said stand-pipe and air-space and opening the compressed-fluid valve on overpressure existing in the vessel, and means for putting the pressure vessel into communication with the atmosphere on cessation of overpressure therein.

708,847. AIR COOLING AND PURIFYING APPARATUS. Carl W. Vollmann, Montreal, Canada. Filed Apr. 13, 1901. Serial No. 55,783.

An air cooling and purifying apparatus, comprising a closed chamber consisting of a cylinder having one end closed by a cap, and its other end closed by a hollow head; a series of perforated pipes within said cylinder and extending longitudinally thereof, and having one end of each closed and the other ends thereof rigidly secured to and communicating with the interior of said head, means for forcing brine into said hollow head; a brine-exhaust port in said closed cylinder, and an air supply to and exhaust from said cylinder.

708,880. SAND-BLAST MACHINE. Frank J. Heideger, West Bridgewater, Pa. Filed Oct. 8, 1901. Serial No. 77,965.

A sand-blast machine, the combination with a closed chest mounted on a vertical axis, a horizontal spindle journaled on said chest and having a work-holder and means for turning the chest on its axis and for revolving the spindle, of a sand-nozzle projecting into the chest, an air-pipe to which said nozzle is connected, an air-valve on said pipe, and means for closing said valve automatically when the chest has turned the requisite distance.

708,944. AIR-PUMP. Edward Walther, Washington, Iowa. Filed Jan. 21, 1902. Serial No. 90,644.

The combination with the storage-bell and a pumping-bell connected by a pipe supplied with check-valves, of a motor-barrel having a piston therein connected to said pumping-bell, a valve constructed to regulate the flow of water into and out of said pumping-bell, a lever connected to operate said valve, a pair of cam-bearing levers, one located on each side of said levers in position to engage and operate said lever, and means connecting said bell and said cam-bearing levers to operate said levers.

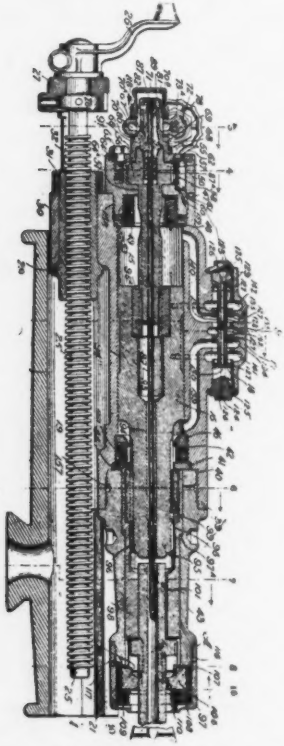
708,973. PNEUMATICALLY-OPERATED LUBRICATOR. Hermann Schmidt, Hamburg, Germany. Filed Dec. 13, 1901. Serial No. 85,765.

In pneumatic lubricating apparatus the combination of a transparent oil-reservoir, a supply-pipe for compressed air leading to the lower part of the said reservoir, an oil-pipe leading from the lower part of said reservoir to the part to be lubricated, an oil-supply reservoir above the level of the part to be lubricated and a pipe leading from the said supply-reservoir to the transparent reservoir.

708,984. METHOD OF TREATING AIR FOR FORCING MALT LIQUORS FROM KEGS. Charles A. Bartliff, St. Louis, Mo. Filed Nov. 8, 1901. Serial No. 81,612.

The herein-described method of treating air for forcing malt liquors from kegs, the same consisting in removing foreign particles from the air, passing the cleansed air through a chamber containing hop-leaves, and delivering the cleansed and impregnated air, under pressure, to the surface of malt liquor in a keg.

709,022. ROCK-DRILLING ENGINE. John G. Leyner, Denver, Colo. Filed July 18, 1901. Serial No. 68,808.

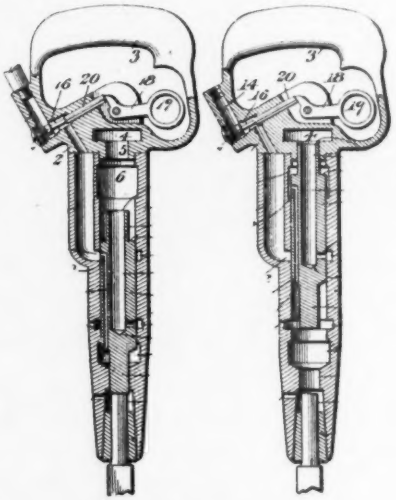


A rock-drilling engine, the combination with the cylinder having a piston-bore and a plurality of counterbores in its front end of different diameters, of a front cylinder-head comprising a tubular member threadedly secured to the largest counterbore of said cylinder, and a steel ring seated in a counterbore against the end of said cylinder-head, a buffer-ring seated in a counterbore against said steel ring, and a steel ring seated in a counterbore against said buffer-ring.

709,030. COMBINATION AIR AND VAPOR MOTOR. Alexander McCahon, St. Joseph, Mo. Filed Aug. 27, 1900. Serial No. 28,155.

The combination in a motor of a vapor-chamber, and the plungers and plunger-guide therein, of a square vertical shaft, of the friction-wheel carried on the bottom thereof, of the main axle and the hub keyed thereto and adapted to contact with said friction-wheel, of a horizontal disk carried by said shaft through a square opening in the center of said disk enlarged at both top and bottom, of the disk-pockets, an aperture leading into the vapor-chamber and with which the disk-pockets are arranged to successively register during the motion of said disk, of the wires thereon, of the spring arranged to contact therewith, of the pipe connection between said pockets and the gasolene-tank which pipe is provided with any suitable means for heating and generating the gas therein, and the means through which to transmit the pressure caused by the explosions into the vapor-chamber from said disk-pockets as each pocket registers with the aperture provided.

709,067. VALVELESS HAMMER. Daniel S. Waugh, Chicago, Ill. Filed Nov. 30, 1900. Serial No. 38,202.



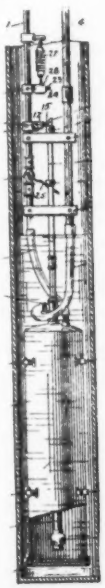
An automatic hammer comprising a casing, a hammer movable therein, means for directing a fluid-pressure against a reduced area of the hammer during its initial movement and

against the whole pressure area during the remainder of its movement in one direction, and means supplemental to the normal exhaust for relieving the compression opposed to the hammer during the final portion of its movement in the opposite direction.

709,181. SAND-BLAST APPARATUS. Theodore A. Sippel, Newark, N. J. Filed Apr. 18, 1902. Serial No. 103,651.

In a sand-blast apparatus, comprising a casing, with the lower portion formed as a hopper for the abrasive material used; a valve to govern the flow of such abrasive material to an inner ejector-nozzle; and a pipe governed by a valve to convey an air-blast to such ejector; said pipe being attached at an angle downward so that the blast it carries may impinge upon and encircle the lower parts of such inner ejector-nozzle, and thus draw the abrasive material with it and force it through a fixed metallic tube connected thereto and adapted to carry it from the ejector at the bottom to a detachably-exchangeable blast-nozzle at the top of said casing, which nozzle extends downwardly therein.

709,212. PNEUMATIC PUMP. Ralph W. Elliott, Oakley, Cal. Filed Feb. 19, 1902. Serial No. 94,784.



The combination of vertical rigid air-inlet and water-outlet pipes, upper and lower horizontal guides extending between the said pipes and connected thereto at their ends, a tank, a rod extending vertically from said tank and slidably guided by said guides, a three-way valve in the air-inlet pipe communicating in one of its positions with the atmosphere, means actuated by said rod for operating the three-way valve, a rigid water-delivery pipe extending to the interior of the cylinder near the bottom thereof, a flexible pipe connection between said latter pipe and the vertical rigid water-outlet pipe, a flexible pipe connection between the air-inlet pipe and the upper end of the tank, and a check-valve in the water-delivery pipe.

709,258. PNEUMATIC RAILWAY-SIGNAL. Cyrus S. Dean, Fort Erie, Canada. Filed Nov. 27, 1901. Serial No. 83,863.

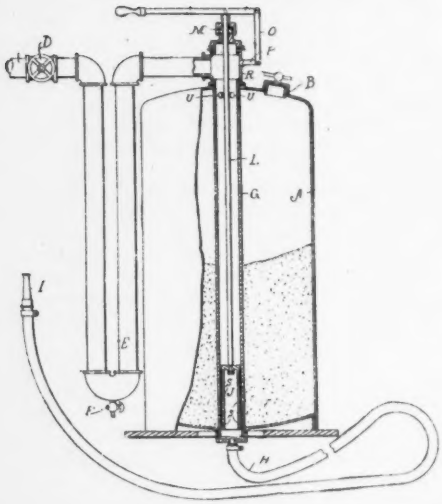
In a railway signaling device, rails, a pneumatic-operated signal, a plurality of air-compressing cylinders, a walking-beam, having connection with the pistons of said cylinders and operating-bars connecting to the extremes of the walking-beam and extending above the rails, whereby the walking-beam is rocked from a passing train.

709,335. PNEUMATIC TORPEDO-FIRING APPARATUS. Simon Lake, Bridgeport, Conn. Filed Jan. 30, 1902. Serial No. 91,871.

In combination, a submarine boat provided with a conning-tower, rising above the hull of the same and normally separated therefrom by a water-tight wall or partition and a torpedo-tube, a compressed-air reservoir and a connection therefrom to the inner end of said torpedo-tube, and devices controlled by means within the conning-tower for admitting compressed air to the torpedo-tube for expelling a torpedo therefrom.

709,448. SAND-BLAST-CONTROLLING APPARATUS. Joseph Shaver, Milwaukee, Wis. Filed Aug. 5, 1901. Renewed July 2, 1902. Serial No. 114,132.

A sand-blast controlling device, the combination of an air-tight sand-receiving reservoir; a cylinder, provided at its lower end with a plurality of apertures through its vertical walls, extending longitudinally through said reservoir; an air-duct communicating from the source of pressure through the upper end of said cylinder with said sand-



reservoir above the sand therein; a hose connected with the lower end of said cylinder; a vertically-moving hollow plunger, provided with apertures at its upper end, located within said cylinder, and adapted to control the passage of sand through said apertures; a rod communicating from said plunger with the exterior of said reservoir; and means for raising and lowering said plunger, and opening and closing said apertures.

709,520. AIR-COMPRESSING APPARATUS. Edward J. St. Croix, Madrone, Wash. Filed Dec. 23, 1901. Serial No. 86,979.

An apparatus for compressing and storing air; a reservoir, a main conduit adapted to convey air under pressure to said reservoir, a gate-valve to control said conduit and a second gate-valve in the conduit closely adjacent to said reservoir, an auxiliary conduit adapted to convey steam to the main conduit and a gate-valve to control same, a driving-cylinder, a branch conduit leading from the main conduit to said cylinder and having a gate-valve therein, a double series of air-compressing cylinders each of less length of bore than said driving-cylinder, said series arranged within the cylinders in tandem and disposed at opposite sides of the center line of the driving-cylinder, a conduit leading from one head of each compression-cylinder to the reservoir and a port of ingress in said end, a check-valve in last said conduit, and a check-valve arranged to control said port, a piston-rod for each series of cylinders and a like rod for the driving-cylinder, oppositely-disposed levers operably connected to the rod of the driving-cylinder and arranged to drive the piston-rods of the compression-cylinders, valve-operating mechanism for the valve of the driving-cylinder operably connected to one of said levers, and a manually-operative air-pump connected to said reservoir.

709,579. APPARATUS FOR SPRAYING AND BURNING LIQUID FUEL. August Köhler, Hamburg, Germany. Filed May 23, 1900. Serial No. 17,634.

An apparatus for spraying and burning liquid fuel, the combination with air and fuel reservoirs and pipes leading therefrom, of a distributing-box having a pivotal connection with said pipes, tubes leading from the distributing-box, and burners carried at the opposite end of said tubes, each of said tubes being pivotally jointed intermediate its respective burner and the distributing-box.

709,647. CARBURETER. Alvin M. Rosenberry, Shelby, Ohio, assignor of one-half to Mack H. Davis, Shelby, Ohio. Filed Dec. 2, 1901. Serial No. 84,404.

In combination with a carbureting-chamber; a normally closed hydrocarbon-feed leading to said chamber; a suitable air-supply also communicating with the chamber; a valve for opening and closing the hydrocarbon-feed; and means connected to said valve and operated by the air passing to the carbureting-chamber from the air-supply, said means opening and closing the valve in proportion to the amount of air-gas withdrawn from the carbureting-chamber.

709,683. ROTARY SLIDE-VALVE FOR PUMPS, COMPRESSORS OR MOTORS. Louis Roedel, Passaic, N. J. Original application filed Mar. 24, 1900. Serial No. 10,026. Divided and this application filed June 28, 1900. Renewed June 10, 1902. Serial No. 111,007.

The combination with two stationary cylinders arranged axially in line with each other and provided with interior inlet and outlet channels, of conical slide-valves at the ends of said cylinders, means for imparting rotary motion to the slide-valves, plungers guided in said cylinders, and means for imparting reciprocating motion to said plungers.

709,763. APPARATUS FOR COOLING AND FILTERING COMPRESSED AIR. Friedrich Grumbacher, Charlottenburg, near Berlin, Germany. Filed June 7, 1902. Serial No. 110,684.

An apparatus for cooling and filtering air comprising a filtering-chamber the filtering layer of which is penetrated by a central pipe, the upper end of the latter fitting tightly into the cover of the filtering-chamber and connected to a supply-pipe, and the lower end of the said central pipe being open, in combination with a system of cooling-pipes arranged within the central pipe and provided at one end with a closed common chamber and connected at the other end respectively with a collecting-chamber and supply-pipe.

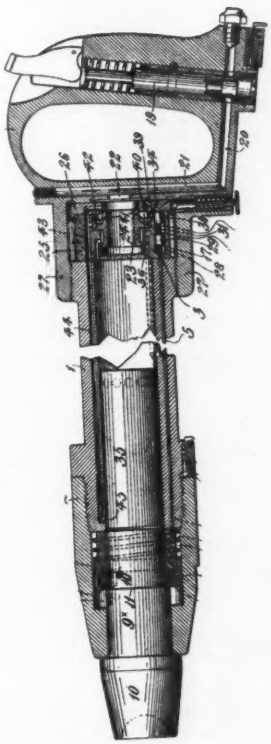
709,830. GAS-BLOWPIPE. George B. Snow, Buffalo, N. Y., assignor to the Snow Dental Company, Buffalo, N. Y., a Corporation of New York. Filed July 27, 1900. Serial No. 24,985.

A gas-blowpipe having a valve-casing, a gas-valve and an air-valve located therein and adapted to be opened by pressure of the finger, a spring for closing said valves, and a screw-cap, threaded upon one end of the casing, whereby said valves are confined therein and suitably adjusted.

709,832. AIR-COMPRESSOR. Willie J. Stevens, Skowhegan, Me., assignor to the Stevens Air Brake Company, Skowhegan, Me., a Corporation. Filed Jan. 3, 1902. Serial No. 88,307.

A compressor, the combination of cylinder, a piston therein, a hollow shaft suitably mounted, a clutch member on the hollow shaft, a pin slidable in the hollow shaft, a second clutch member moved by the pin into engagement with the clutch member on the hollow shaft, an eccentric on the hollow shaft, a piston-rod and eccentric-strap, a controlling-cylinder on the cylinder-head of the first-named cylinder, a piston therein, a spring engaging the piston, a reservoir, a valve between the reservoir and controlling-cylinder, a piston-rod extending through one head of the controlling-cylinder, and levers connecting the piston-rod and pin.

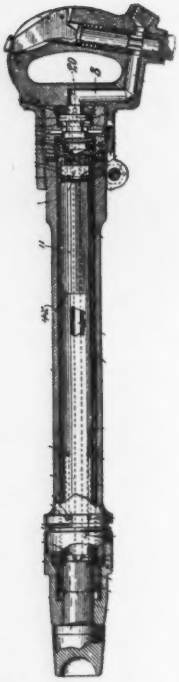
710,196. PNEUMATIC TOOL. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Filed Sept. 20, 1901. Serial No. 75,764.



A pneumatic riveter or other tool, the combination of a nosepiece adapted to have the shank of a working tool inserted therein, and a retaining device contained within said nosepiece and adapted to engage said shank, in combination with a distribution-valve, means for controlling said valve and mechanism intermediate said retaining device and said means for controlling said valve, whereby the latter is operated.

710,197. PNEUMATIC RIVETER. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Filed Mar. 22, 1902. Serial No. 99,490.

A pneumatic riveter, a cylinder, a handle, an extension or sleeve on said handle in threaded engagement with said cylinder, a valve-box within said extension, a distribution-valve and a stop-valve contained within said valve-box, lugs projecting from said ex-



tension, a slot between said lugs, and a threaded bolt passing freely through one of said lugs and being in threaded engagement with the other of said lugs, said bolt having a jam-nut therefor.

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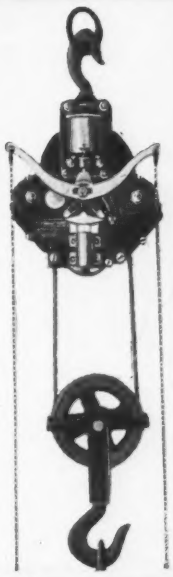

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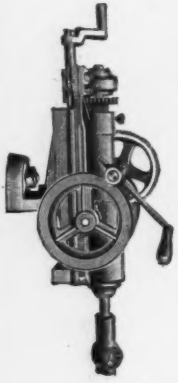

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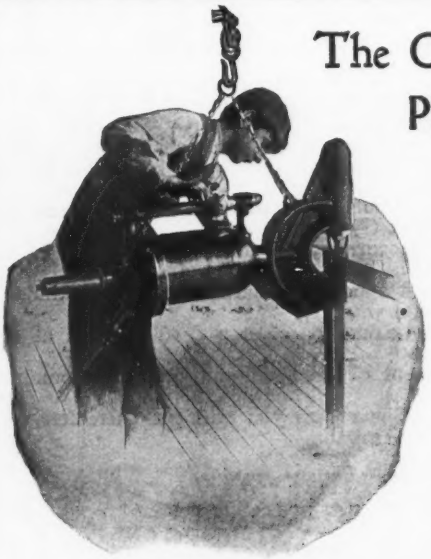

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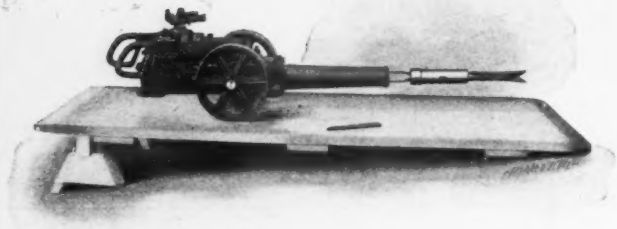

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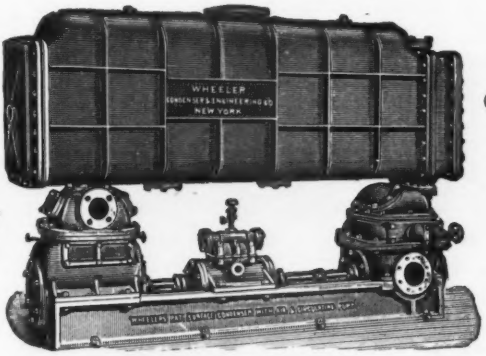

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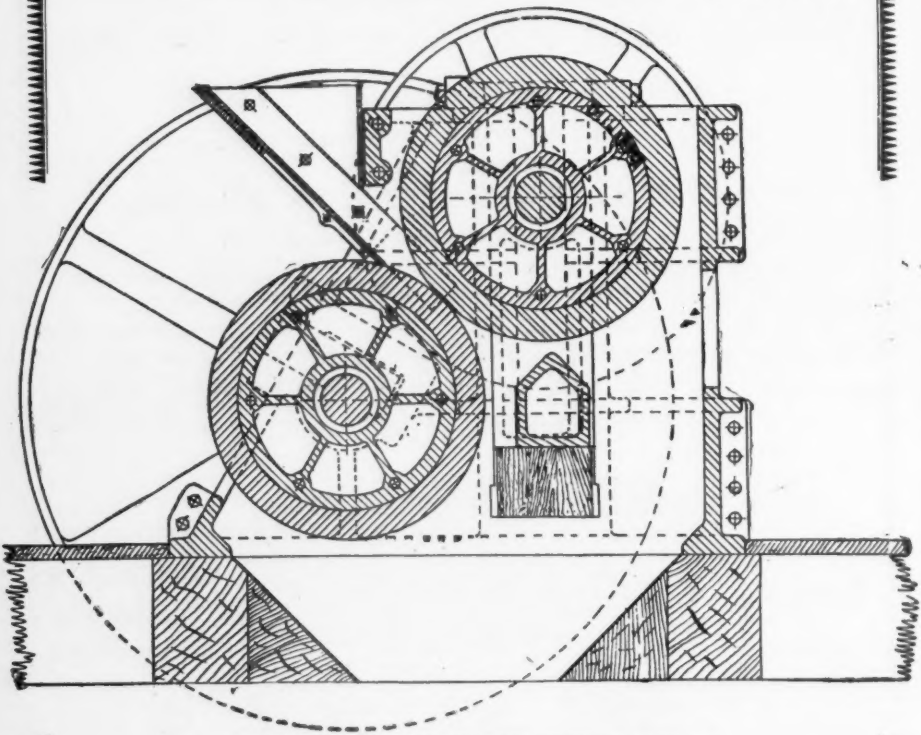

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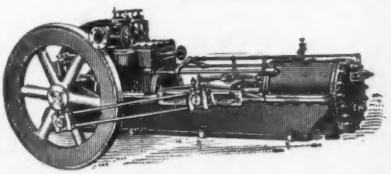

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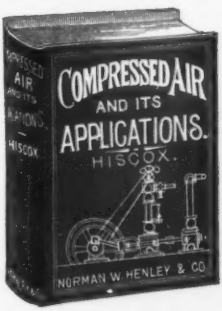

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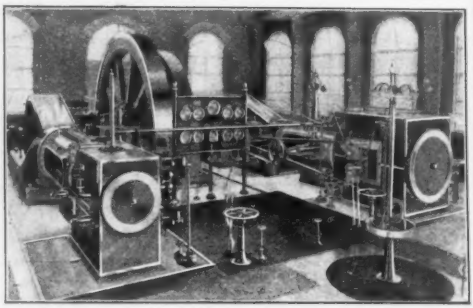

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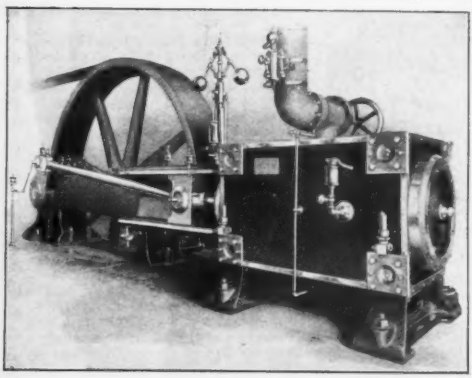

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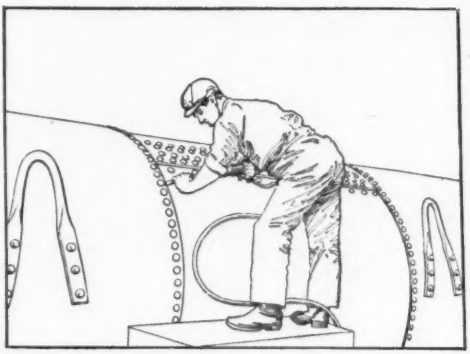

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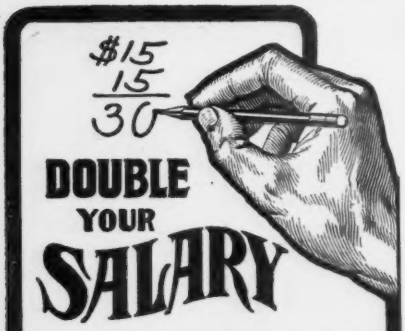

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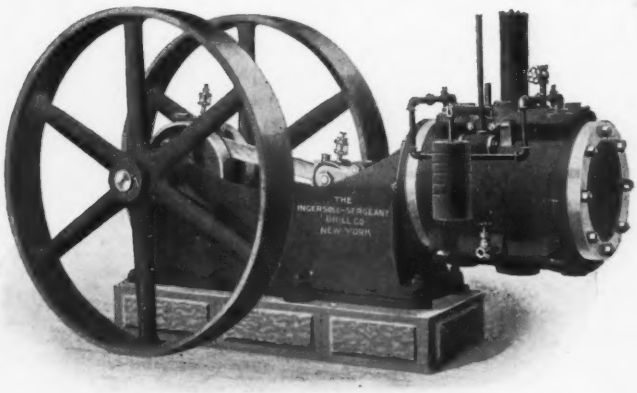

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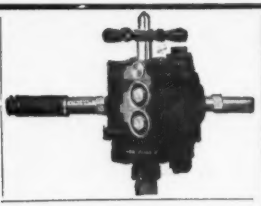

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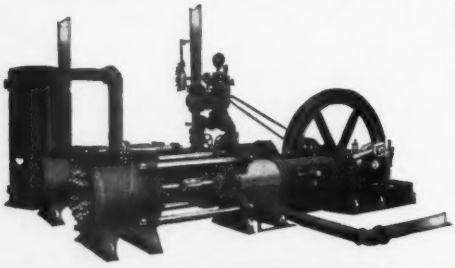

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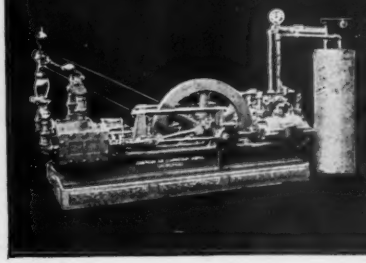

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